PROGRESSIVE TECHNICAL SERIES

PROGRESSIVE DRAFTING

BOOK I.

JAS. G. SINCLAIR

AL

BC
744
S61b
v.1

THE CLARKE & STUART COMPANY LIMITED

REFERENCE

406

DISCARDED
FROM
LEGISLATIVE LIBRARY
VICTORIA

PROVINCIAL LIBRARY,
VICTORIA, B. C.

PROGRESSIVE TECHNICAL SERIES

PROGRESSIVE DRAFTING

BOOK I.

JAS. G. SINCLAIR
Principal
TECHNICAL SCHOOL
Vancouver, B. C.

THE CLARKE & STUART COMPANY LIMITED
VANCOUVER, B.C.
1934

PROVINCIAL LIBRARY

144
S616
v.1

COPYRIGHT, CANADA, 1934
BY THE CLARKE & STUART COMPANY LIMITED

PRINTED IN CANADA
THE CLARKE & STUART COMPANY LIMITED

FOREWORD

With the advent of another book on Drafting an explanation is necessary.

There are many good books on the subject in the field today, but there has been a need for some time past for a handbook that would meet the requirements of Junior High Schools, Junior Technical Schools and Senior High Schools and Technical High Schools. Existing books profess too much, and matter irrelevant to purely school work is often introduced. All Engineering and Shop Drawing needs the same broad foundational work, and it is the aim of Progressive Drafting to give this fundamental basis only, apart from all divergencies into technical aspects of the subject.

The author, Mr. Jas. G. Sinclair, Principal of Vancouver Technical School, has had a long experience teaching the subject, both in Day and Night School, and he has selected methods he has found best for the teaching of the subject.

Progressive Drafting does not invade the field of Mechanical Drawing or any particular line of Drawing, but confines itself to the necessary work preliminary to the study of the specialized phases of the subject.

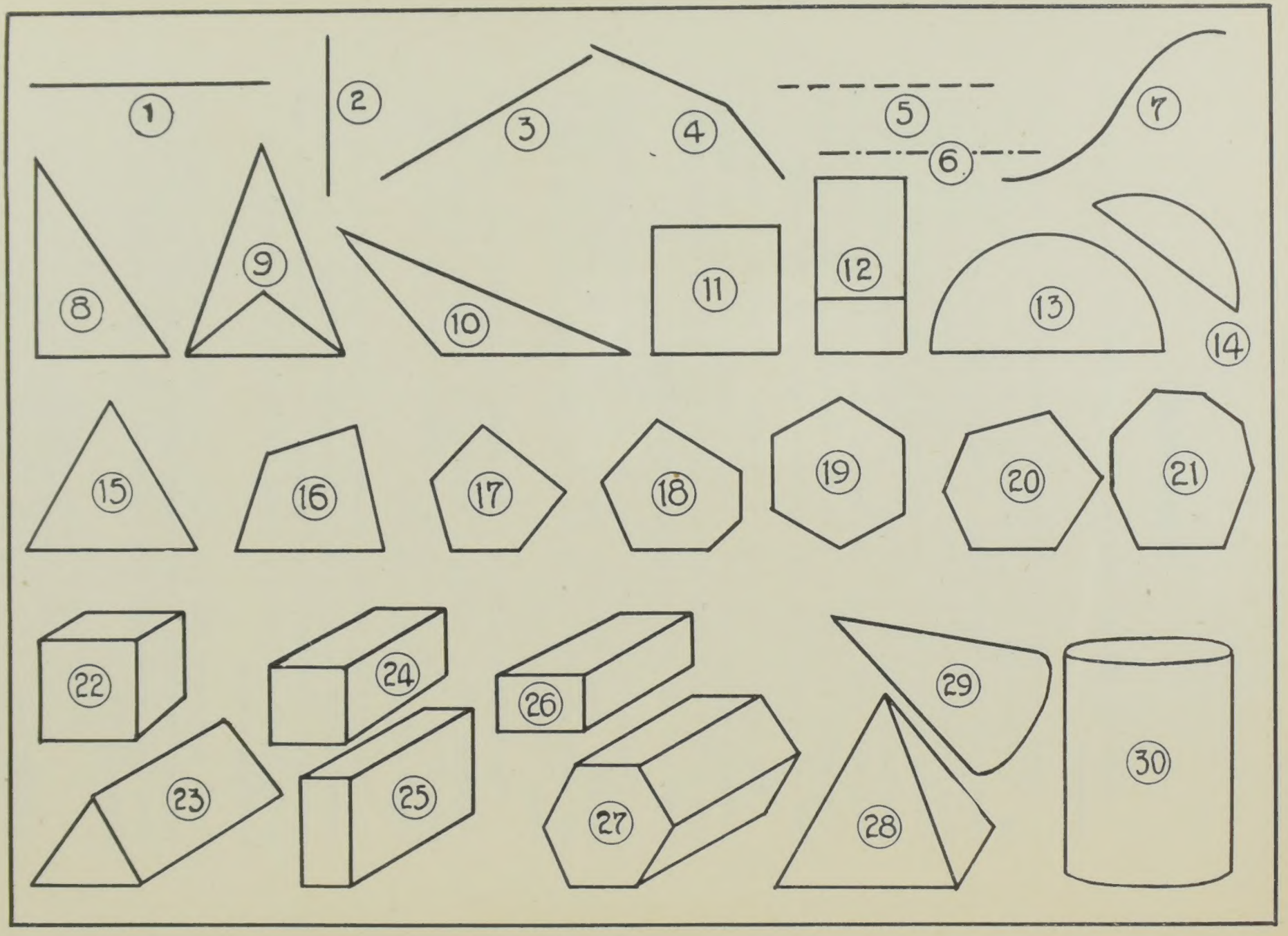
The book is made in a limp cover, in a handy size and at a reasonable price, making it possible for use as a regular classroom book. The usual type of Drafting text book is too large, too clumsy, and too expensive.

The teaching method is contrary to the usual style, and the presentation is revolutionary. The author has tried to make every exercise a thinking subject instead of a mechanical exercise, and in the hands of a good teacher, the book will be found to be of excellent service.

It is assumed that the student has already a certain amount of working knowledge of the simpler drawing tools, and, therefore, the usual long preliminary description of tools and material has been dispensed with.

169646

REFERENCE SHEET



REFERENCE SHEET

On the opposite page are certain drawings the names of which you must know.

A straight line is the shortest distance between two points and it has no breadth, Fig. 1 is only the representation of a straight line. You can measure its breadth. If you fold a sheet of paper, the creased line at the fold is a true line. You can see it, but cannot measure its width.

Fig. 1 represents a horizontal line, because it lies flat like the horizon. Fig. 2 shows a vertical line, straight up and down. If you hang a weight suspended on a string, the string is vertical. Carpenters use this kind of line to get verticals. Fig. 3 shows an oblique or slanting line. Fig. 4 shows a zig-zag or crooked line, which you can see is made up of two straight lines. Fig. 5 is a dotted line, and is very hard to draw correctly. Fig 6 shows a chain line, and Fig. 7 represents a curved line, no part of which is straight.

Figs. 8, 9, 10 show different types of triangles. Fig. 8 is a right-angled triangle. Fig. 9 is an isosceles triangle, with two sides equal. Fig. 10 is a scalene triangle, which has all its sides unequal. It is also an obtuse-angled triangle, because it has one angle larger than a right-angle.

Fig. 11 is a square, with all its sides equal, and all its angles right-angles. Fig. 12 shows three rectangles. A rectangle has its opposite sides equal, and all its angles right-angles. Fig. 13 is a semi-circle, or half a circle. Fig. 14 shows part of a circle. The curved line is called an arc, and the straight line a chord.

The next set shows you different figures. Fig. 15 is a triangle, 3 sides. Fig. 16 is a quadrilateral, 4 sides. Fig. 17 is a pentagon, 5 sides. Fig. 18 and 19 are hexagons, 6 sides. Fig. 20 is a heptagon, 7 sides, and Fig. 21 is an octagon, 8 sides.

Figures are regular or irregular. A regular figure has all its sides equal, like the hexagon in Fig. 19. An irregular figure has not all its sides equal, as the hexagon in Fig. 18.

Under the term quadrilateral you have different figures, as the square, rectangle, parallelogram. Figures with more than 4 sides are given the general name "polygon", which means many angles.

Figs. 22 to 30 represent solids, which are different from figures. How so?

Fig. 22 is a cube, with square faces on every side.

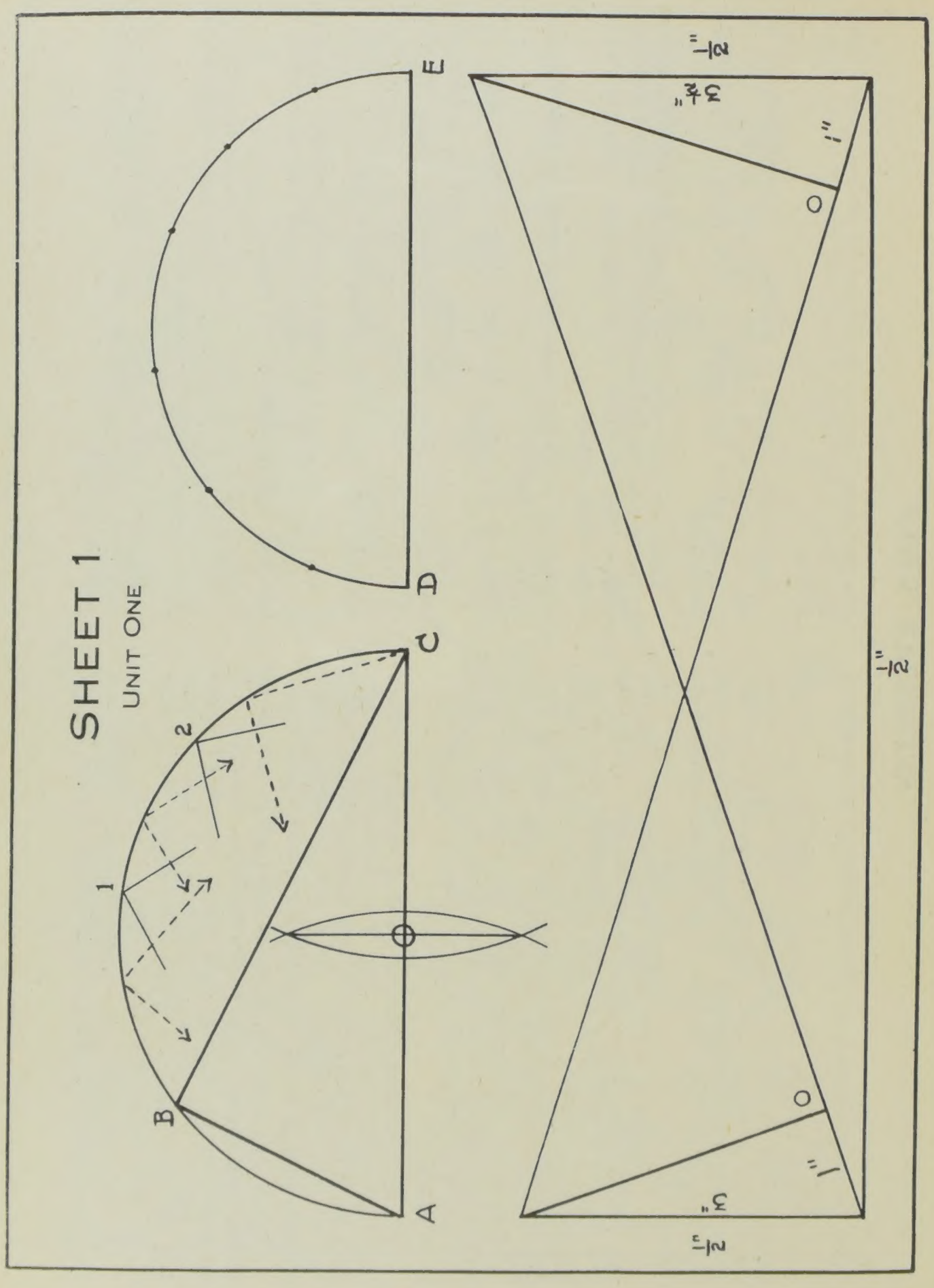
Figs. 23 to 27 are prisms. A prism is a solid with rectangles for sides, and with varying shapes for ends. The prism is named from the shape of its end. Fig. 23 is a triangular prism; Figs. 24, 25, 26 are rectangular prisms, while Fig. 27 is a hexagonal prism.

Fig. 28 represents a regular square pyramid. (Its base is a square; its apex or top is exactly over the middle of the base, and its sides are all equal.)

Fig. 29 is a right cone. (It has a circular base, and the apex is exactly over the centre of the base. Has the cone any connection with the pyramid?)

Fig. 30 is a right cylinder. (The base is circular and the side is at right angles to the base. Has it any connection with the prism?)

SHEET 1—UNIT ONE



SHEET 1—UNIT ONE

Tools: Square, ruler, compasses, 9″x12″ paper.

Lesson: Accuracy in placing points.

Did you ever think that geometry is nearly entirely concerned with the placing of points?

A line of fixed length is terminated by two points. A triangle has three fixed points. A square has four fixed points. A circle is composed of an infinite number of points placed in a fixed relation.

Any line is the path made by a point in motion.

In Sheet 1 you are asked to place points as follows: Place one at each corner of your sheet, each being ½″ from each edge of your paper. Join these points to get an oblong or rectangle, which is a figure with opposite sides equal, and its angles right angles.

Measure the distance from one corner point to the opposite corner point, this line being called the diagonal, or the measure through from corner to corner. This length should be 13 6/10″. If your measurement is not correct, (1) your border lines must be wrong, (2) your paper is not squared, or (3) the paper is not 9″x12″.

Measure your other diagonal. If it is the same length as your first diagonal, then your paper has been cut square, for the diagonals of a rectangle are equal. If both diagonals are 13 6/10″, your drawing is correct, and your paper correct. But if one diagonal is correct and the other wrong, find out exactly where the error lies.

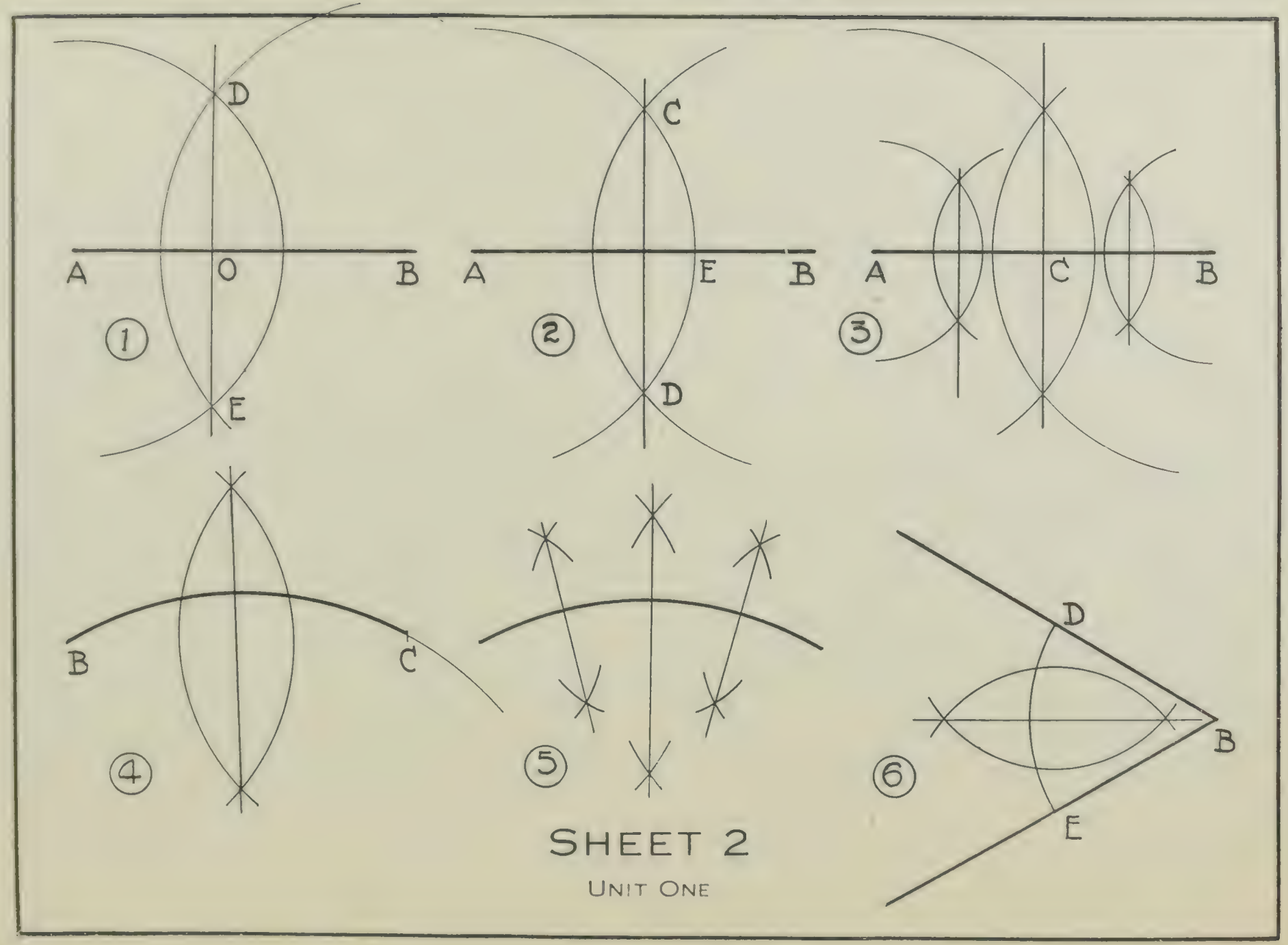
Place these points: A is 1″ from left edge and 4″ down from top edge. B is 2″ from left edge and 2″ from top edge. C is 6″ from left edge and 4″ from top edge.

Join these points and get the triangle ABC. Take your set square and place it on the angle ABC. The square angle on your set-square should fit the angle ABC. If not, your drawing is wrong. Check up, and correct.

Take your compasses and extend to a distance greater than half of AC. From the centres A and C sweep parts of circles, or arcs, so that they cut as shown. Mark the point O. With O as centre and OA in your compasses sweep an arc to go from A to C. This is known as a semi-circle, or half a circle. B should now lie on this arc.

Take your set-square and place its right angle as shown by the dotted lines. In these positions you can swing your square so that its sides will go through A and C. An angle in a semi-circle is always a right angle. The angles at 1 and 2 are right angles. Are they angles in this semi-circle?

Make a semi-circle without compasses, Fig. 2. Copy diagram in Fig. 3.


D
A
O
B
1
E
C
A
E
B
2
D
A
C
B
3
B
C
4
5
D
B
6
E
SHEET 2
UNIT ONE

Tools: Square, ruler, compasses, 9″x12″ paper.

Place a half-inch border around your paper.

In Sheet 1 you cut a line into two equal parts. Look it up.

Fig. 1. Bisecting a line. Place a line AB 3″ long, with A and B 2½″ down and A 1″ in from left edge. With A as centre, and any radius greater than half of AB, swing an arc. With B as centre, and any radius greater than half of AB, swing an arc, cutting the first arc in D and E. Join DE. Measure AO and BO. Very likely they are not equal.

Fig. 2. Draw another AB 3″ long and ½″ away from the original B. From what you have learned from Fig. 1 bisect this line.

Fig. 3. Draw another AB 3″ long and ½″ away from last AB. Divide this line into 4 equal parts. Do this by first bisecting at C and then bisecting the halves AC and CB.

A tidy boy always has his shoe laces neatly tied and never trailing on the ground. How could you better these three drawings?

Look at the arc CED in Fig. 2. Measure CE and DE with your compasses. You will find them equal. You have bisected the arc CED.

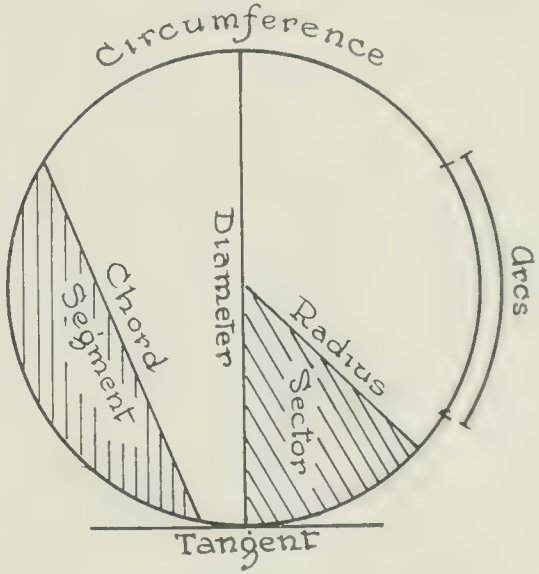
Fig. 4. Place a point A on your bottom border line 2½″ in from left edge. With 3″ in your compasses, sweep an arc. Find a point B on this arc 1″ in from left edge. With 3″ in your compasses and B as centre, cut the arc at C. Could you find a shorter cut from B to C than by going round by the arc?

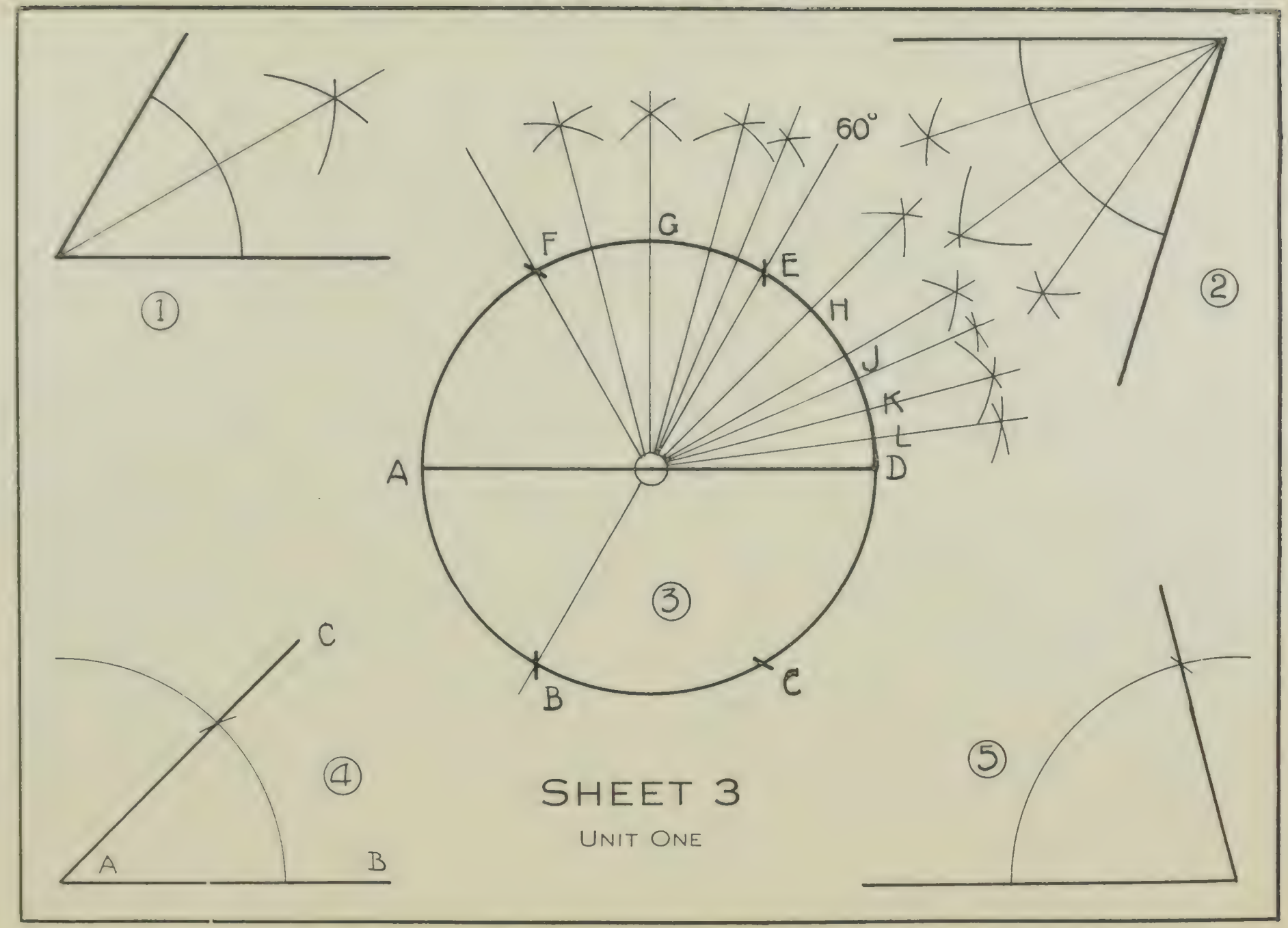
To bisect this arc, proceed as in Fig. 2.

Fig. 5. To divide an arc into 4 equal parts. Proceed as in Fig. 3. Check up with your compasses. Check up where the bisectors meet when produced.

Fig. 6. To bisect an angle. With B as centre, and any radius, sweep an arc in the angle as DE. Bisect DE as in Fig. 4. You will find that the bisecting line should pass through centre B. Remember this when you take up Sheet 3.

In your next lesson you are to meet the circle. The more you know about the circle the more you will wish to learn. The circle used to be the sign of eternity, without beginning and without end; but when people began to use it in geometry they had to find a beginning in order to get an end. The early geometricians with very crude tools found out wonderful things about the circle, and this knowledge has been handed down to us, and increased with the years. Learn these parts of a circle before going any further.




1
2
3
4
5
60°
A
B
C
D
E
F
G
H
J
K
L
SHEET 3
UNIT ONE

SHEET 3—UNIT ONE

Tools: Square, ruler, compasses.

Lesson: The construction of angles.

An angle is made by the meeting of two straight lines. There are three types: (a) Right angle, such as you have on your square; (b) Acute angle, which is "sharp", and less than a Right angle; (c) Obtuse angle, "blunt", greater than a Right angle.

People talk of an angle of 45 degrees. This is not strictly correct. In every angle you can sweep an arc, and it is this arc that contains the degrees.

In Fig. 1 you locate any two lines to form an angle. You have to bisect this angle. You simply bisect the arc which you put in this angle, and which you do as in Fig. 6 in last sheet.

In Fig. 2 you have to divide the angle into four equal parts. You should be able to see how this is done.

Now you come to a very important lesson. You have to construct certain angles.

Sweep a circle of 2″ radius, whose center is the middle of the paper. Put in the horizontal diameter AD. You do this by finding the point A which is the point nearest the left edge of your paper. Now with your radius in your compasses, step around the circle, and see where you finish up. You should have gone around six steps, and finished up exactly on A.

A radius steps around its circle exactly six times, but remember that the length AB on the circle is larger than your radius AB. Why is this?

A long time ago the circumference of the circle was divided into 360 equal parts. As was said before, you had to have a start somewhere, and know where you were going on the circumference. These divisions were called degrees, and were written thus, 45°, 67°, 145°.

By stepping off your six equal spaces around the circle, you placed in each space 360° divided by 6, giving you 60° of arc. DE thus has 60° of arc. By joining EO you form the angle EOD. This angle contains an arc of 60°. Therefore we say that the angle EOD is an angle of 60°.

Join FO. How big is the angle FOD?

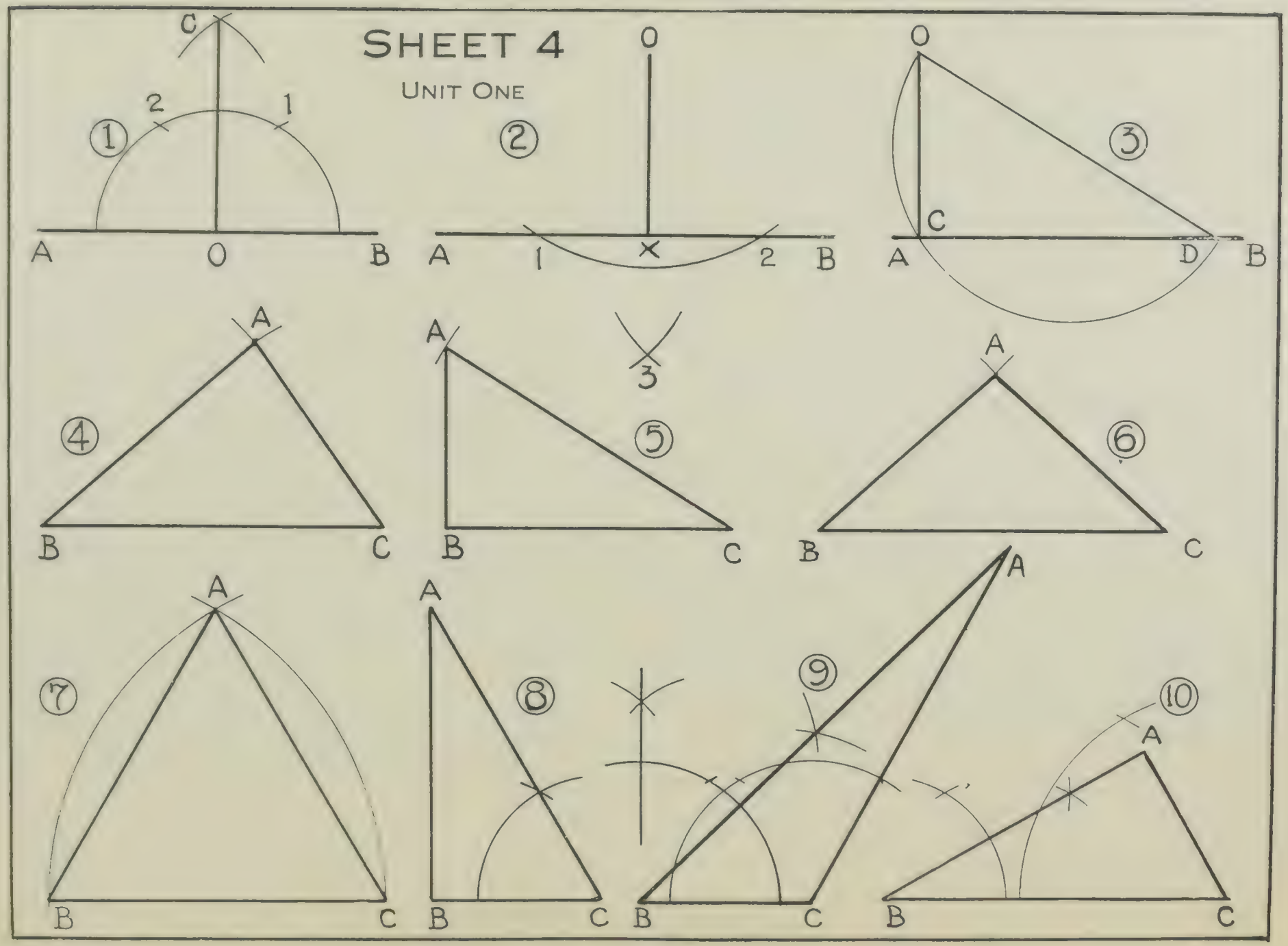
Bisect the arc FE, which has 60°. FG now contains 30°. How big is the angle DOG? How many degrees in a right angle? How many right angles can you have around a point? How many degrees in the angles AOD and DOB?

Bisect GD. How big is HOD? Bisect ED. How many degrees in JD? Bisect JD, GH, GE, KD, FG, and state the size of the arcs commencing from D.

In Fig. 4 place AB as shown. Make BAC equal to 45° by taking the radius of your circle in Fig. 3 and swinging it from A. Lift in your compasses 45° of arc from your centre circle and mark it off from AB. Angle BAC is 45°. Similarly in Fig. 5, make an angle of 75°.

All the angles you can make with your compasses are part of 60°. You cannot make an angle of 25°, 16°, 125°. You can get these on a protractor, an instrument that gives you any angle you want.

PROVINCIAL LIBRARY, VICTORIA, B. C.


SHEET 4
UNIT ONE
1
2
3
4
5
6
7
8
9
10
A
B
C
D
O
X

SHEET 4—UNIT ONE

Tools: Square, ruler, compasses, 9″x12″ paper.

Lesson: Making perpendiculars.

A perpendicular is a line that is at right angles to another line. How is it different from a vertical line? Draw sketches of perpendicular lines in different positions.

Place 3 lines AB, as in drawing. You have to raise perpendiculars from the point O in each case.

Fig. 1. Sweep a semi-circle from centre O. With the radius in your compasses, cut the semi-circle in 1 and 2. Find where the third cut comes. How many degrees of arc from 1 to 2?

Bisect arc 1 2. Join CO. CO is perpendicular to AB.

Fig. 2. O is outside AB. From centre O swing arc to cut AB in 1 and 2. Bisect the arc 1 2. Join O to 3. OX is perpendicular to AB.

Fig. 3. O is over the end of AB. Take a point D near B. Join OD; bisect it, and construct a semi-circle which cuts AB in C. Join CO. COD is the angle in a semi-circle. (See Sheet 1).

Figs. 4 - 9 are concerned with making triangles. Fig. 4 has AB=2½″, BC=3″ and CA=2″.

Lay BC horizontally, and with AB, or 2½″, in your compasses, swing an arc from centre B. With centre C and with AC, or 2″, as radius, swing an arc to cut the first arc. Join AB and AC.

Fig. 5 has the angle ABC 90°, BC 2½″, and AC 3″.

Lay BC horizontally. Set up 90° with your square, and with AC, or 3″, in your compasses, and with centre C, swing an arc to cut the perpendicular in A.

Fig. 6 is an isosceles triangle with AB and AC=2″, and BC=3″. You should be able to do this without instruction.

Fig. 7 is an equilateral triangle with 3″ sides.

Fig. 8 is a right-angled triangle with B the right angle, C an angle of 60°, and BC=1½″.

Fig. 9 has BC=1½″, the angle B=45°, and angle C=120°.

Fig. 10 has BC=3″, angle B=30°, angle C=60°.

In Fig. 7 AC has 60° of arc, AB has 60° of arc; therefore angles B and C have each 60°. All the angles of an equilateral triangle are equal. Therefore, angle A has also 60°. You can prove this by swinging arc AC with centre A. In stepping off your radius from C, you will find it cuts at B.

The triangle ABC has 3 angles of 60°, therefore 180° all told.

In Fig. 8, B is 90°, C is 60°. Measure A. It should be 30°. A+B+C=30°+90°+60°=180° or 2 right angles.

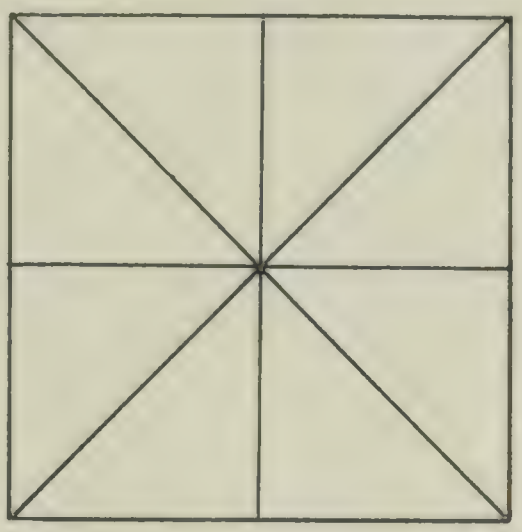
In Fig. 9, B is 45°, C is 120°. How big should A be?

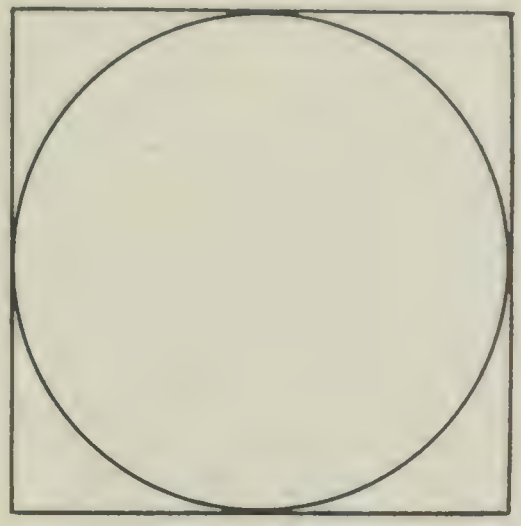
You may assume meantime that the sum of the angles in a triangle equals two right angles.

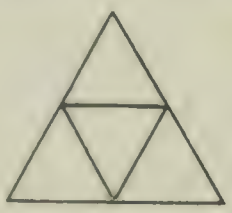
In Fig. 9, if B were given as 75° and C as 120°, how would you solve such a problem?

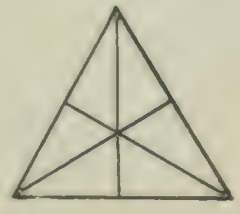
Try to make these triangles: AB 1½″, BC=3″, AC 1″, AB=4″, BC=2″, AC=1¾″. If you can make triangles, you must have erred somewhere. Find your error.

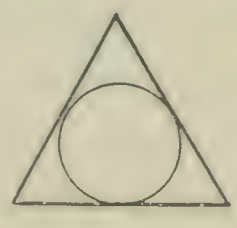
Lesson: The sum of the angles in a triangle is equal to 180°. Any two sides of a triangle must be greater than the third side.











TRACERY

Tools: Square, ruler, compasses, 9″x12″ paper.

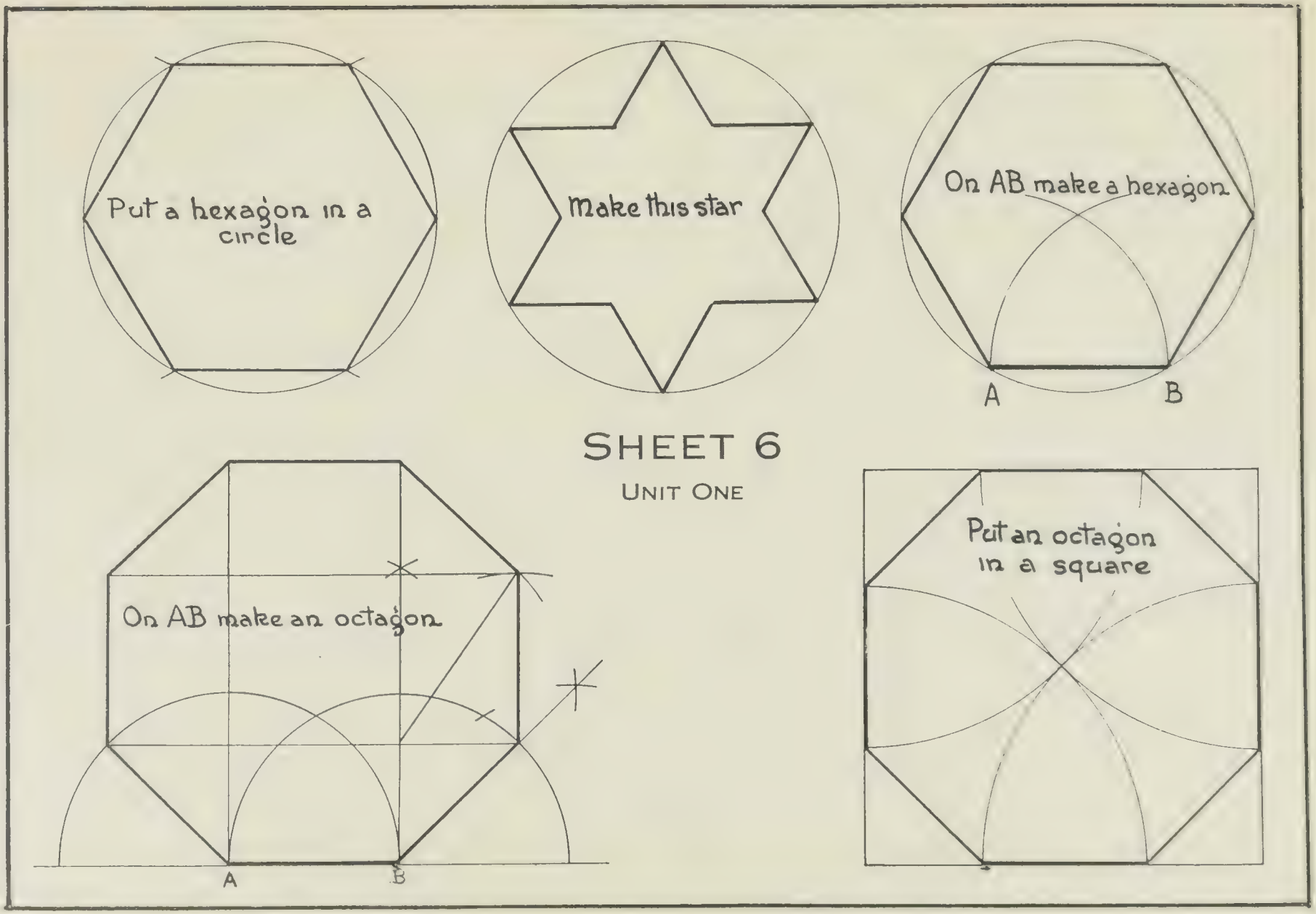
This type of sheet is given to test your accuracy. Make the three squares with 3″ sides, and use your set square for the angles.

When you have finished a square, test for its squareness. Do not rely on your set square. The one test for squares and rectangles is to measure the diagonals, which must be equal. If they are not equal your square is not square.

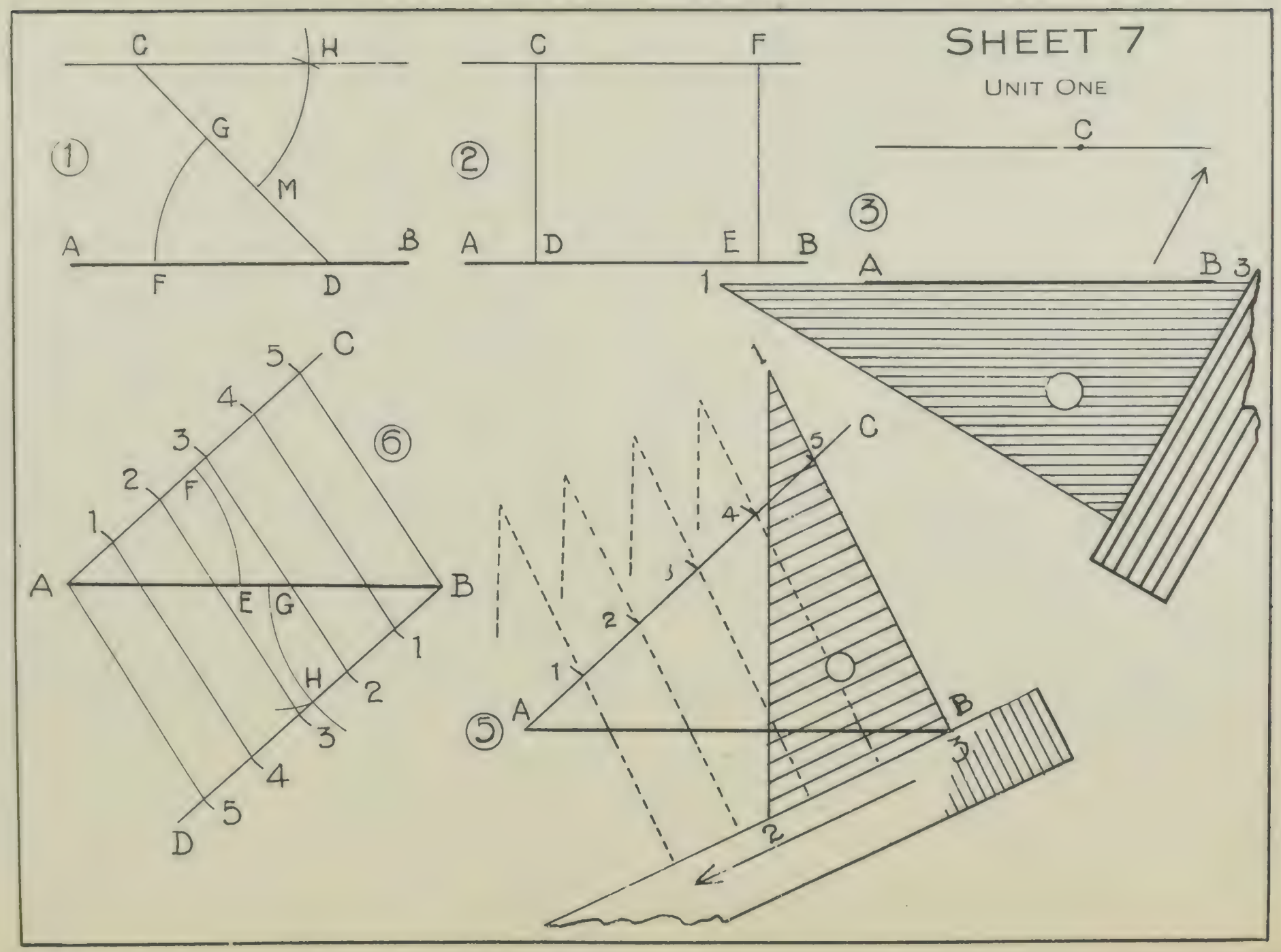
Watch carefully the joinings of lines. The center of the circle in Fig. 3 is the intersection of the diagonals. In the lower half of the paper you have to set three equilateral triangles of 3″ side. See that the base lines are all in line.

When you feel that you have done these exercises well, you can try to put a circle inside the inner square in Fig 1; 4 circles in Fig. 2, and 2 squares one inside the other in Fig. 3.

In the lower half, put a circle in the inside triangle in Fig. 4, and a triangle in the circle in Fig. 6.


Put a hexagon in a circle
Make this star
On AB make a hexagon
A
B
SHEET 6
UNIT ONE
On AB make an octagon
A
B
Put an octagon in a square

SHEET 7—UNIT ONE



SHEET 7—UNIT ONE

Tools: Set squares, ruler, compasses, 9"x12" paper.

Parallel lines are the same distance apart all the way, and can never meet. What would happen if railway lines were not parallel? You can have two parallel lines, or any number you wish.

Fig. 1. Show how to draw a line through a point C parallel to a given line AB. Take any point D in AB. Join CD. Sweep an arc FG in the angle ADC. At C sweep an arc of the same radius as the first. Measure the arc FG, and set it off on the second arc as HM. Join CH and produce it both ways. This line is parallel to AB.

You will notice that you made the angle HCM equal to the angle ADC.

Fig. 2 This is the same problem as above. Drop CD with your square perpendicular to AB. At any point in AB, as E, raise a perpendicular. Make EF equal to CD. Join CF and produce both ways. CF is parallel to AB.

Fig. 3. Same problem. This is the easiest and fastest method.

Set your square with one side on AB. Set a ruler against either of the other sides. *Keep this ruler always in the same position.* Now slide your square along the ruler so that 1 3 rises above AB. In every position in its rise 1 3 is parallel to AB. When 1 3 hits the point C, draw a line through C, which will now be parallel to AB.

Fig. 4. To cut a line AB into any number of equal parts, say 5.

At A make the angle BAC. Sweep the arc EF in this angle. At B sweep an arc with the same radius as first arc. Step off EF on this arc as GH. Draw the line BHD. In what relation does BD stand to AB?

On AC step off 5 units as 1, 2, 3, 4, 5.

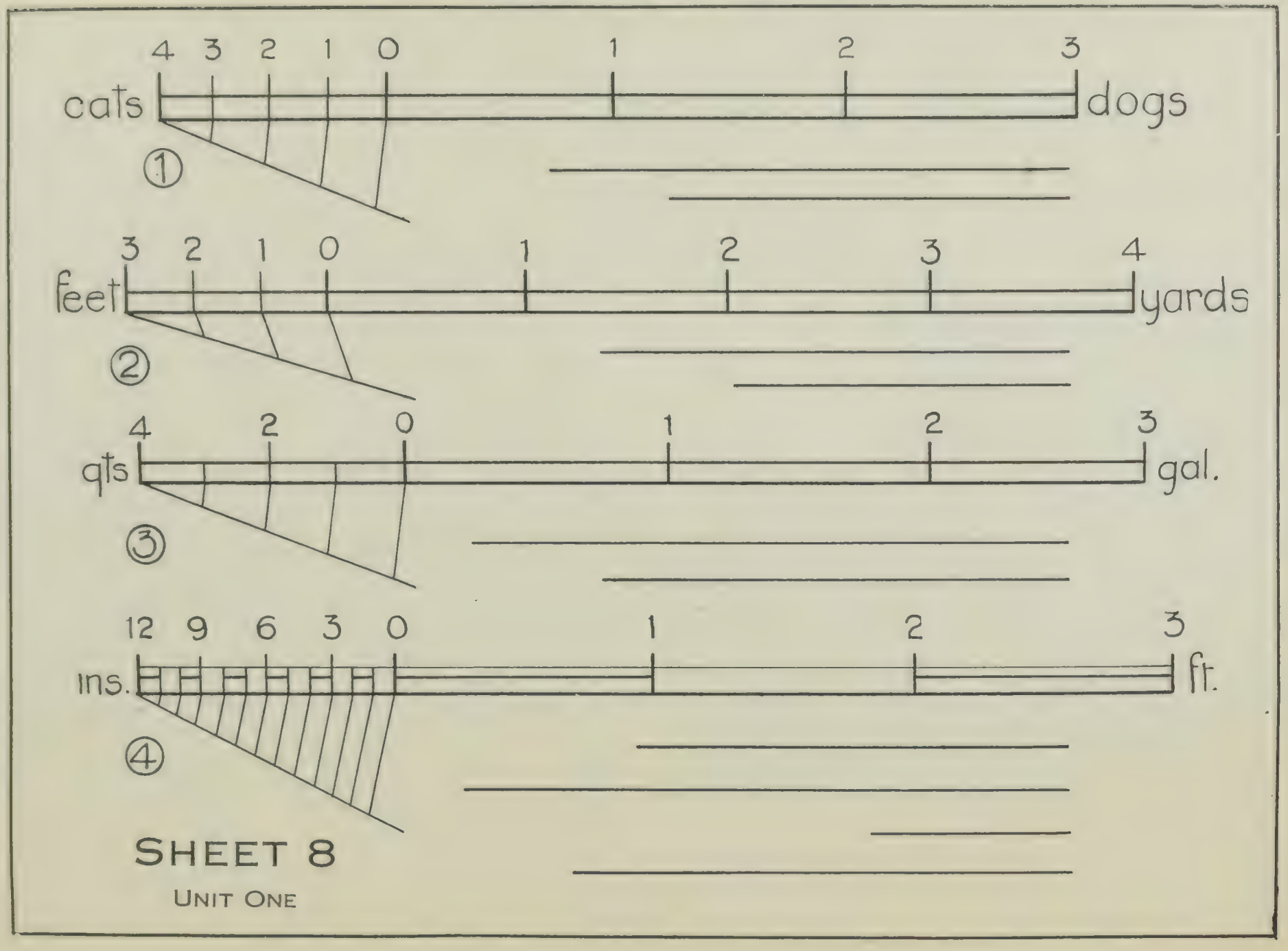
On BD step off the same units.

Join 5B, 4 1, 3 2, 2 3, 1 4, A5. AB is divided into 5 equal parts where these lines intersect it.

Fig. 5 shows the set square method for solving the same problem.

At A make any angle BAC. Step off on AC 5 equal units. Set one edge of your set square on 5 and B, and join 5B. Set your ruler against the bottom of your square, *and keep it fixed in that position.* Slide your square along the ruler till the side 1 3 is now on division 4. Draw your new line 1 3. Continue this method with the other points, and you will get four lines parallel to your first 1 3. These four lines cut AB into 5 equal parts.

Exercise: Divide a line in the proportion of 2, 3, 5.


4 3 2 1 0 1 2 3
cats
dogs
1
3 2 1 0 1 2 3 4
feet
yards
2
4 2 0 1 2 3
qts
gal.
3
12 9 6 3 0 1 2 3
ins.
ft.
4
SHEET 8
UNIT ONE

SHEET 8—UNIT ONE

SCALE DRAWING—

The average boy should not meet much difficulty in the matter of making and using simple plain scales.

Making a scale drawing of any drawing or object is simply reducing it or enlarging it so that all the parts bear the same proportion to each other as they do in the original. Sometimes the teaching of the lesson asks too much in the beginning, and the learner does not get his feet firmly on the ground. Suppose you were asked to make a scale to represent dogs and cats, and were given no more details, the matter would be impossible. No person makes a scale to represent dogs and cats without certain details. But if four cats are equal to one dog, and a dog is to be shown by a line of two inches, then a scale can be made. You have also to draw a line below your scale to show a total length of 2 dogs and 3 cats, as in Fig. 1. In making a scale you must first get your unit of length which, in this case, is two inches.

Lay off on a line 4 divisions of the unit of 2 inches. *Now forget that this unit is 2 inches.* Each unit now represents one dog. Erect ½″ perpendiculars at each unit mark and draw a line across, half way up. All these units represent one dog. Each unit also represents 4 cats. Letter "dogs" at the right end of your scale, and "cats" at the left end. The first unit is to be subdivided into 4 equal parts. Place 4 as indicated. Divide the unit as shown, and as you have done on Sheet 7. Complete the unit as shown, and put on the figures 4, 3, 2, 1. Naturally the next upright line must be O, which is the dividing line. Counting from O to the right you have 3 units or 3 dogs. Figure so.

To measure a length of 2 dogs and 3 cats: place one point of your compasses or dividers on the right hand 2. Stretch out to O. You have now 2 dogs. Stretch further to the 3 on the left. You have now added 3 cats. The total stretch represents 2 dogs and 3 cats, which length place below your scale as shown.

Also draw a line to represent 1 dog and 3 cats, and also a line to show 1 dog and 6 cats.

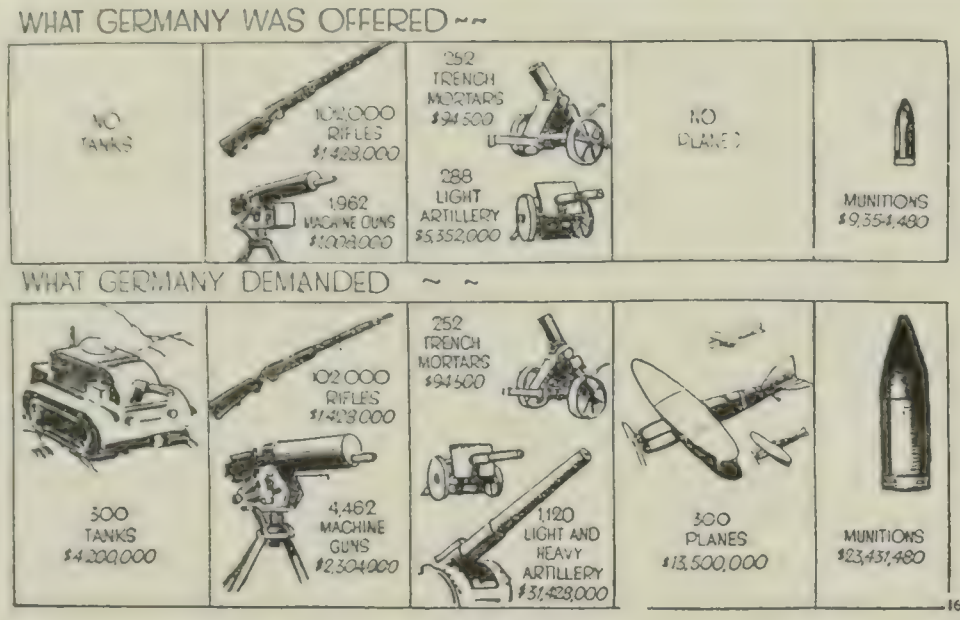
Fig. 2. Make a scale to show feet and yards where a yard is shown by 1¾″. Draw a length of 2 yards 1 foot, and 1 yard 2 feet.

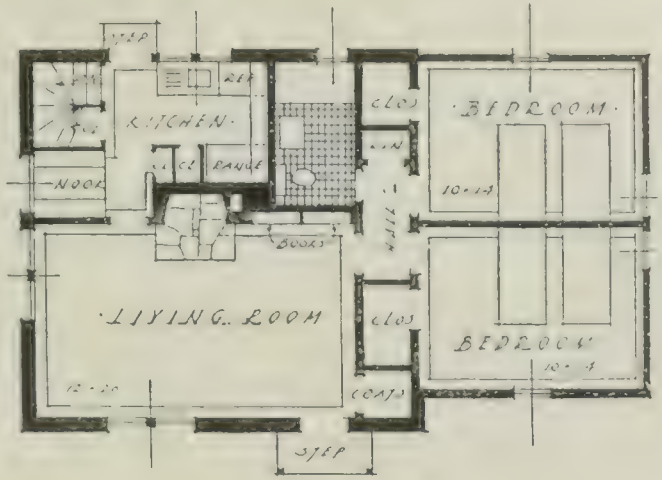
Fig. 3. Make a scale to show quarts and gallons where a gallon is represented by 2″. Show a length of 2 gallons 1 quart, and 1 gallon 3 quarts.

Fig. 4. Make a scale to show feet and inches where a foot is represented by 2¼″. Show lines of 1′ 8″, 2′ 4″, 9″, 1′ 11″.

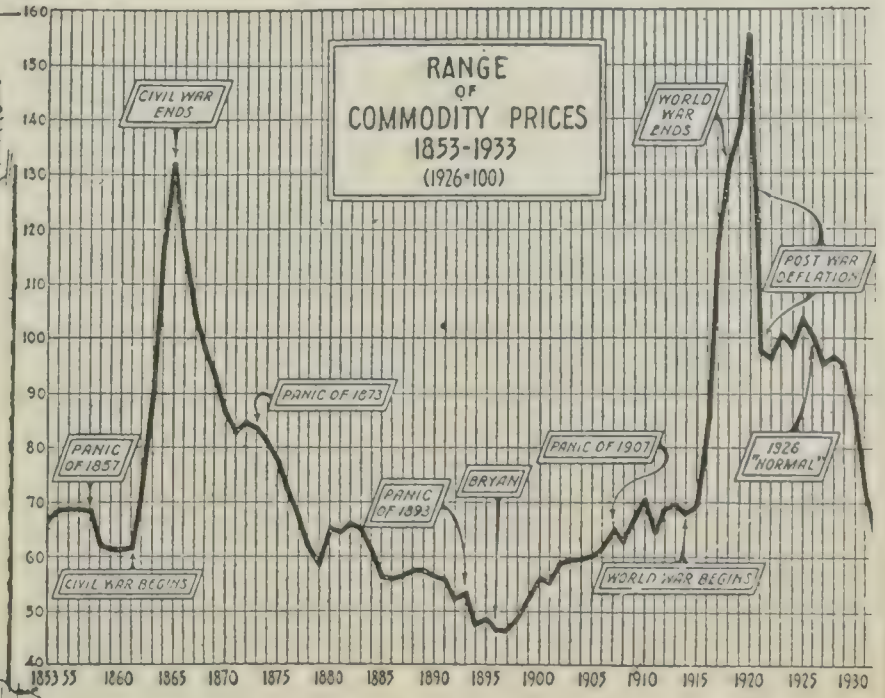
Scales can be bought ready made, but they are all scales of length. These scale rulers usually are made triangular in section with the different scales on the different sides. All maps and house plans are drawn to scale. Graph lines in newspapers showing volume of trade, population, etc., are all scale lines. Making or reading a scale drawing should be quite easy if you can intelligently make a scale of your own, as in this sheet.

The next page gives you scale drawings clipped from newspapers.

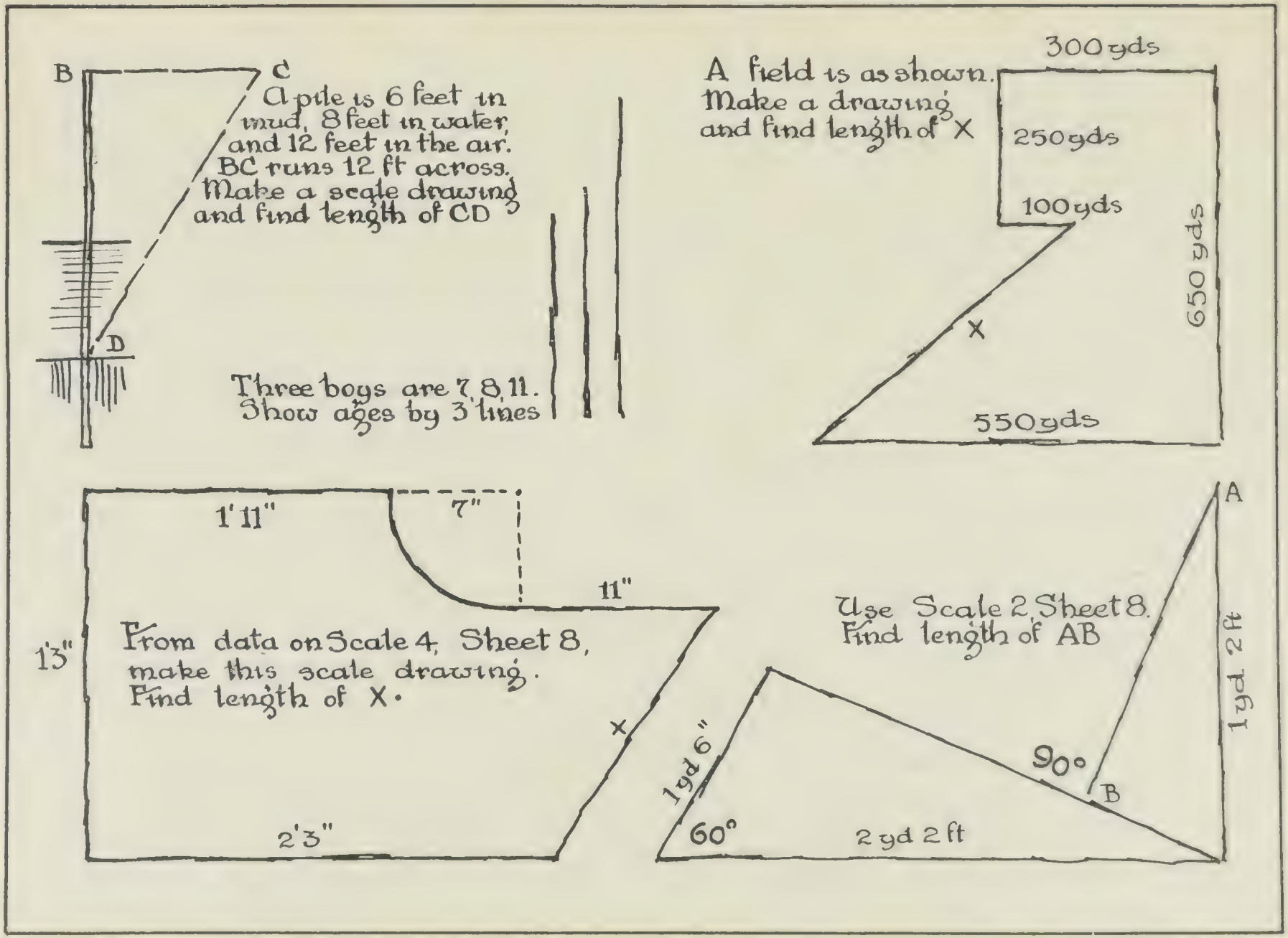

WHAT GERMANY WAS OFFERED ~~
NO TANKS
102,000 RIFLES $1,428,000
1,962 MACHINE GUNS $1,028,000
252 TRENCH MORTARS $94,500
288 LIGHT ARTILLERY $5,352,000
NO PLANES
MUNITIONS $9,354,480
WHAT GERMANY DEMANDED ~ ~
300 TANKS $4,200,000
102,000 RIFLES $1,428,000
4,462 MACHINE GUNS $2,304,000
252 TRENCH MORTARS $94,500
1,120 LIGHT AND HEAVY ARTILLERY $31,428,000
300 PLANES $13,500,000
MUNITIONS $23,431,480


KITCHEN
NOOK
RANGE
REF
CLOS
BEDROOM
10'-4"
HALL
DOORS
LIVING ROOM
12'-10"
COATS
STEP

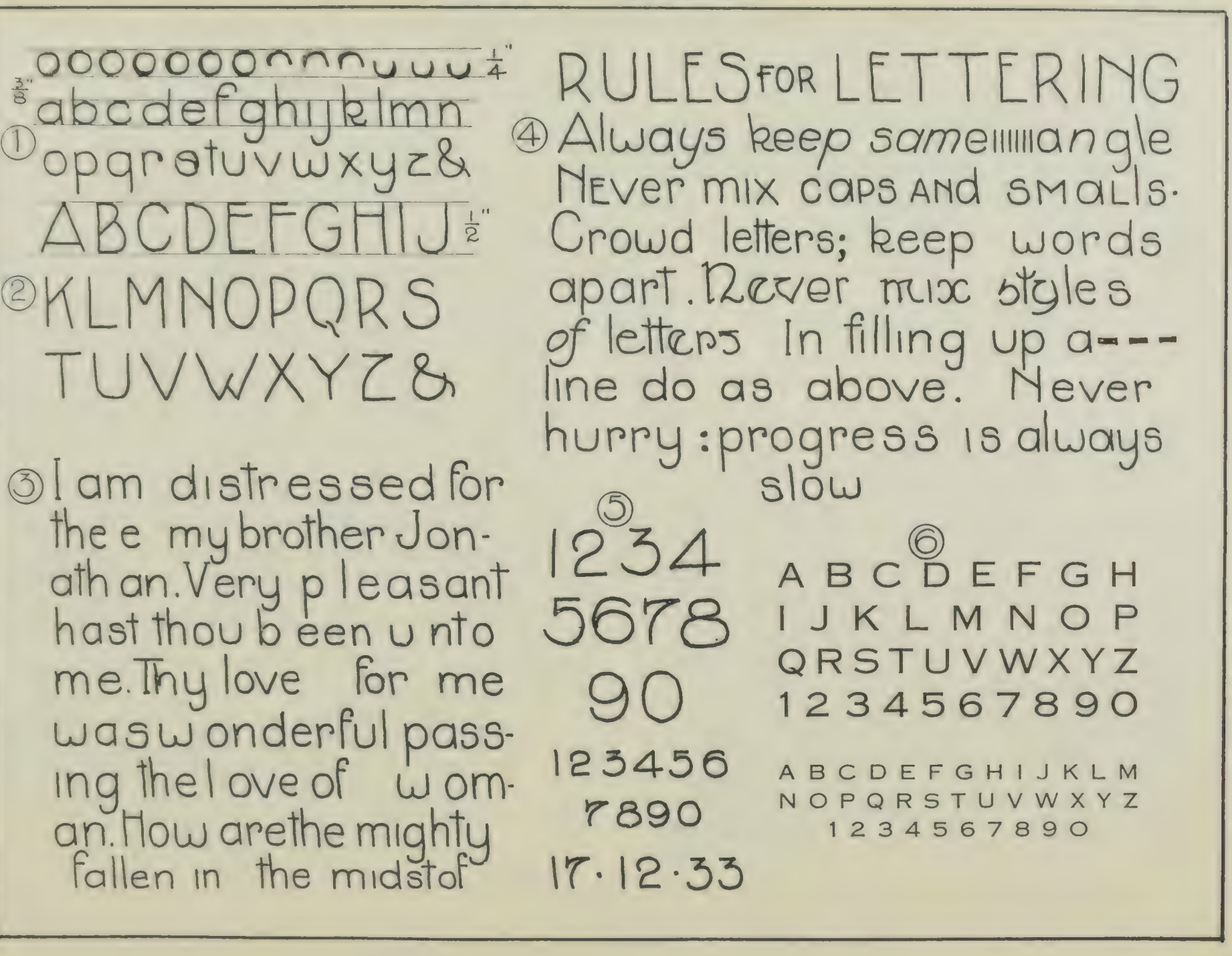
ENGLISH BAY
STANLEY PARK
CENTRE
2ND NARROWS
VICTORIA DR.
FALSE CRK.
TERMINAL AVE.
1ST AVE.
ALMA RD.
BURRARD
16TH AVE.
16TH - 18TH AV.
POINT GREY
FRASER AVE.
VANCOUVER EAST
FRASER RIVER


RANGE OF COMMODITY PRICES 1853-1933 (1926=100)
CIVIL WAR ENDS
WORLD WAR ENDS
POST WAR DEFLATION
PANIC OF 1873
PANIC OF 1857
PANIC OF 1893
BRYAN
PANIC OF 1907
1926 "NORMAL"
CIVIL WAR BEGINS
WORLD WAR BEGINS
160
150
140
130
120
110
100
90
80
70
60
50
40
1853 55
1860
1865
1870
1875
1880
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930

SHEET 9—UNIT ONE. SCALE DRAWING



PROVINCIAL LIBRARY, VICTORIA, B.C.


1/4"
3/8"
abcdefghijklmn
①
opqrstuvwxyz&
ABCDEFGHIJ
1/2"
②
KLMNOPQRS
TUVWXYZ&
③ I am distressed for
the e my brother Jon-
ath an. Very p leasant
hast thou b een u nto
me. Thy love for me
was w onderful pass-
ing the l ove of w om-
an. How are the mighty
fallen in the midst of
RULES FOR LETTERING
④ Always keep same angle
Never mix caps and smalls.
Crowd letters; keep words
apart. Never mix styles
of letters In filling up a---
line do as above. Never
hurry: progress is always
slow
⑤
1234
5678
90
123456
7890
17·12·33
⑥
A B C D E F G H
I J K L M N O P
Q R S T U V W X Y Z
1 2 3 4 5 6 7 8 9 0
A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z
1 2 3 4 5 6 7 8 9 0

LETTERING

You have now come to about the most difficult thing in drafting. So far you have put no printed legends on your sheets. Make up your mind that you are to attack this sheet in the proper spirit. Good lettering takes a long time to learn, and needs endless practice.

This sheet shows you examples of freehand lettering. The small letters are called lower case, and you will observe that they are founded on the **o** and a straight line. The capitals belong to no particular type, but are simple freehand letters.

On a practice sheet rule off lines one quarter of an inch apart, and three eighths space to the next line. Never attempt to letter without guide lines. Make a few lines of the letter **o**, going first in one direction and then in the other. Never mind if you cross the lines or get the letters fuzzy and thick. You must learn to get into the swing. Then do a series of the top half of the **o**, and then a series of the bottom half. Did you notice that when you came towards the end of the line your letters began to take the slope of your handwriting? Guard against this.

Learn: Vertical lettering looks better than sloping.

A vertical line is the line of strength.

A horizontal line is the line of repose.

A sloping line is the line of motion and shows weakness.

The **o** is the basis of the small letters on this sheet.

After you think you have mastered the **o**, try out several small alphabets. Watch the **s**. It has to go into an **o**.

Then take up the capitals, and draw them freehand. Keep practising till you are tired. Then take up the figures in Fig. 5.

Now copy "SHEET ONE—UNIT ONE," and do your name in capitals. You have to put the titles and your name on all your sheets, but do not do so until you are sure you can do the work fairly well.

If you study a page of lettering you will find that it always gives you the idea of a well filled rectangle, and the side lines seem always straight. The printer has to know his job to get this effect. Now print carefully in a rectangle the rules for lettering. One most important rule is missing. Memorize these rules. When you have finished this work, examine and criticize the lettering in Fig. 3. Take a rectangle 4"x5" and try to do Fig. 3 better, and follow the rules.

Fig. 6 shows a simple commercial type of letter. There is beauty in simplicity. As you proceed in lettering you will be inclined to let yourself do flowery styles, but you will come back to simplicity. Good lettering must be easy to look at and easy to read.

The work you will do in this sheet is merely practice work. Later on you will look at this sheet and smile.

UNIT ONE EXERCISES

ACCURACY WORK.

1. Draw a 5″ diameter circle and put a rectangle 3″x4″ inside it.
2. Draw a 5″ circle and put an equilateral triangle inside it.
3. Draw a 5″ circle and put an octagonal star inside it.
4. Draw a 6″ square. Put an octagonal star inside it.
5. Draw a hexagon on a 2″ side. Put a circle inside it.
6. Draw a 2″ side octagon. Put 4 squares inside it.
7. Make a 6″ square and put a straight-lined pattern in it.
8. Make a 6″ square and put a circular pattern inside.

TRIANGLES.

9. Make the following triangles:—
   a. AB=3″, BC=4″, CA=5″. Could you enclose this with a semicircle? How big is the angle ABC?
   b. AB=3″, BC=1½″, AC=3″. What is the name of this triangle?
   c. AB=3″, all the angles are 60°. Name the triangle.
   d. BC=4″, angle A=60°. Name the triangle.
   e. AB and AC each=3″, and the altitude is 2¾″. What kind of triangle is this? How long is BC?
   f. An isosceles triangle has its side 3″ long, and its altitude is 1½″.
   g. AB=1½″, angle B=75°, AC=2½″.
   h. Draw any irregular triangle ABC. Bisect the sides. Join these points to opposite angles. These lines all intersect at one point. Do this in cardboard. Suspend the triangle by a string from this point of intersection. What do you notice?
   i. Draw any irregular triangle. Drop perpendiculars from the opposite corners. Bisect the angles. Bisect the sides and raise perpendiculars. What do you notice?

RIGHT-ANGLED TRIANGLES.

10. a. Base BC=3½″. Side AC=2″.
    b. Base BC=3½″. Hypotenuse AB=4″. The hypotenuse is the longest line in a right-angled triangle, and is opposite the right angle.
    c. Base BC not given, AC=2½″. Hypotenuse AB=4½″.
    d. Base BC=3½″, angle ABC=30°.
    e. Side AC=2″, base angle 30°.
    f. Hypotenuse AB=4″, angle ABC=30°.
    g. Base BC=3½″, angle BAC=60°.
    h. Side AC=2½″, angle BAC=45°.
    i. Hypotenuse AB=4″, angle BAC=60°.

    The above questions contain the nine cases of right-angled triangles.

SCALE DRAWING.

11. a. Divide a line in the proportion of 2″, 1½″, 3″.
    b. If you asked your mother for a quadrant of pie, how much do you expect to get? If she gives you a sextant, how much did she hold back? You

have not been told about these terms, but try to figure them out.

c. Divide a circular pie into pieces in the proportion of 1, 2, 3.

d. Make a scale to show rats and monkeys, where six rats are equal to one monkey, and a monkey represented by 1½″. Show 3 monkeys 5 rats.

e. Make a rough drawing of the room door with dimensions, and then make a scale drawing.

f. A ladder extends 12′ up a wall, and is 9′ away from the wall at the bottom. How long is the ladder?

g. A field is 40 rods by 60 rods. How much distance do I save by cutting across the corner instead of going around by the sides? Make a scale drawing.

h. An airman, half a mile up, drops with a parachute. He travels in a slanting line a total falling distance of ¾ of a mile before touching the ground. How far has he drifted? Make a diagram.

i. An airman leaves the ground and flies a mile and a half at an angle of 30°. Then he flattens out and flies horizontally for six miles. Then he flies up at an angle of 75° for 3 miles. How far is he from his starting point? Make a diagram.

j. In 1933 a town had a population of 30,000. In 1923 it had 20,000, and in 1913, 15,000. Show by a diagram of lines.

12. How could a carpenter know that a wall is straight up-and-down when he has only a piece of string and no spirit level? Is the door jamb in your room straight up-and-down? Get a piece of string and find out.

13. On the floor of your room draw a chalk line and divide it into 5 equal units. Take a piece of string and measure 4 units on it, and with a piece of chalk at one end of the string, swing an arc from one end of your chalk line, just as you would do with compasses. Measure 3 units on your string and from the other end of your chalk line swing an arc to cut your first one. This is a rough way of making a right angle on a floor or on the ground. Notice the proportion, 3, 4, 5.

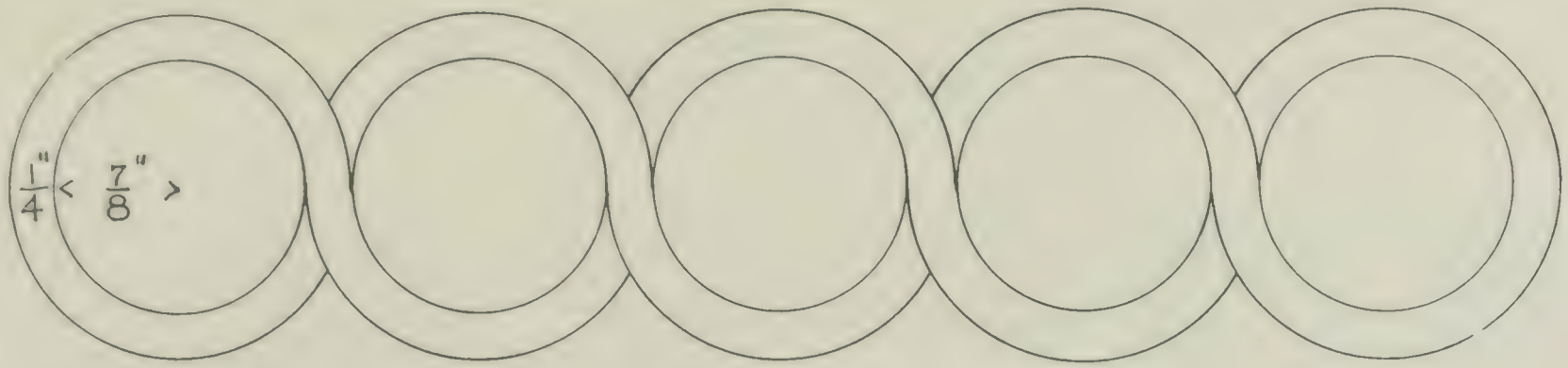
14. Can you make this triangle: AB=2½″, BC=4″, AC=1″?

15. State in writing what you have found out in the above exercise.

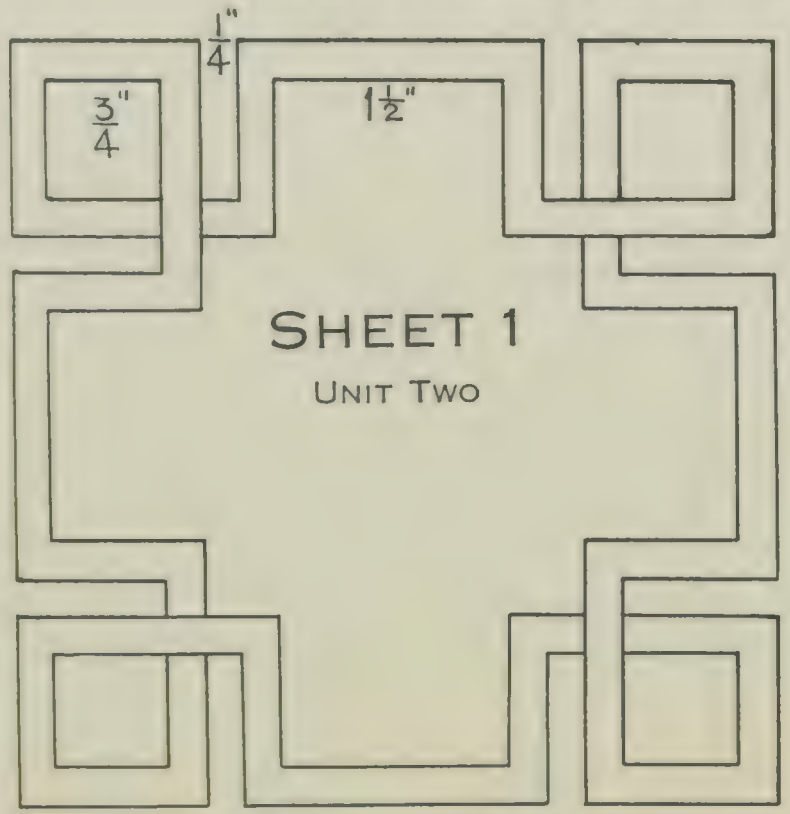
16. In a space 3″x5″ point all the figures as in Fig. 5, Sheet 10. Make the figures ⅜″ high, and with a distance of ½″ between the lines of figures. Rub out your border lines. The whole should now appear as a rectangle if you have followed the rules.

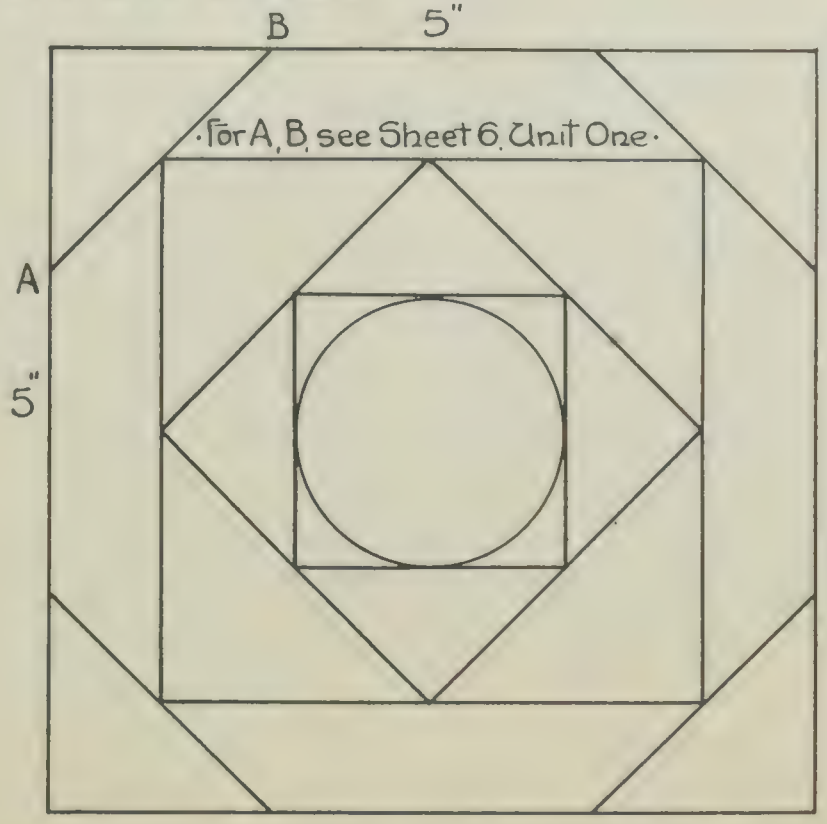
17. In a space 4″x7″ letter your name and home address, the lettering to be half an inch high, with the spacing between to suit the rectangle. Copy the commercial text in Fig. 6, Sheet 10. After lightly sketching in, erase all lines, and harden up letters and border lines.

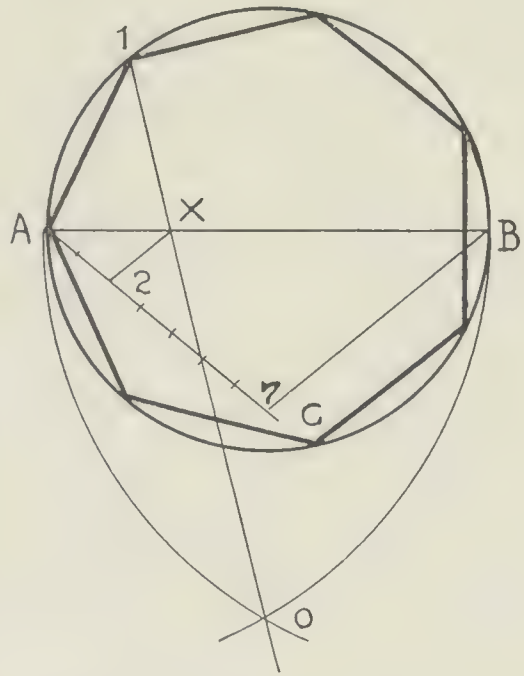
SHEET 1—UNIT TWO



·DO THIS SHEET WITH GIVEN SIZES·

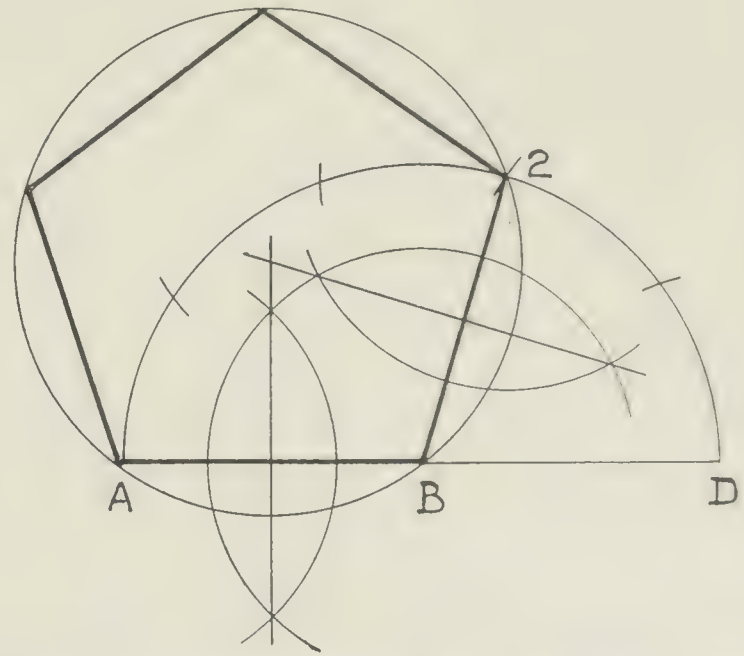






SHEET 2

UNIT TWO



To inscribe any regular polygon in a given circle: Take a circle of 2″ radius and put a heptagon inside (Reference Sheet). Draw diameter AB. Draw AC at any angle and set off on it as many equal spaces as the figure is to have sides, in this case, 7. Mark points 2 and 7. Join 7B, and through 2 draw 2X parallel to 7B. (X is the point you are after.) Swing arcs from A and B with radius AB to cut in O. Join OX and produce it to meet circumference in 1. A1 is one seventh of circumference. Step it around. (If you are only one quarter of an inch out the error is not serious, as you have been increasing your error every step from point 1.)

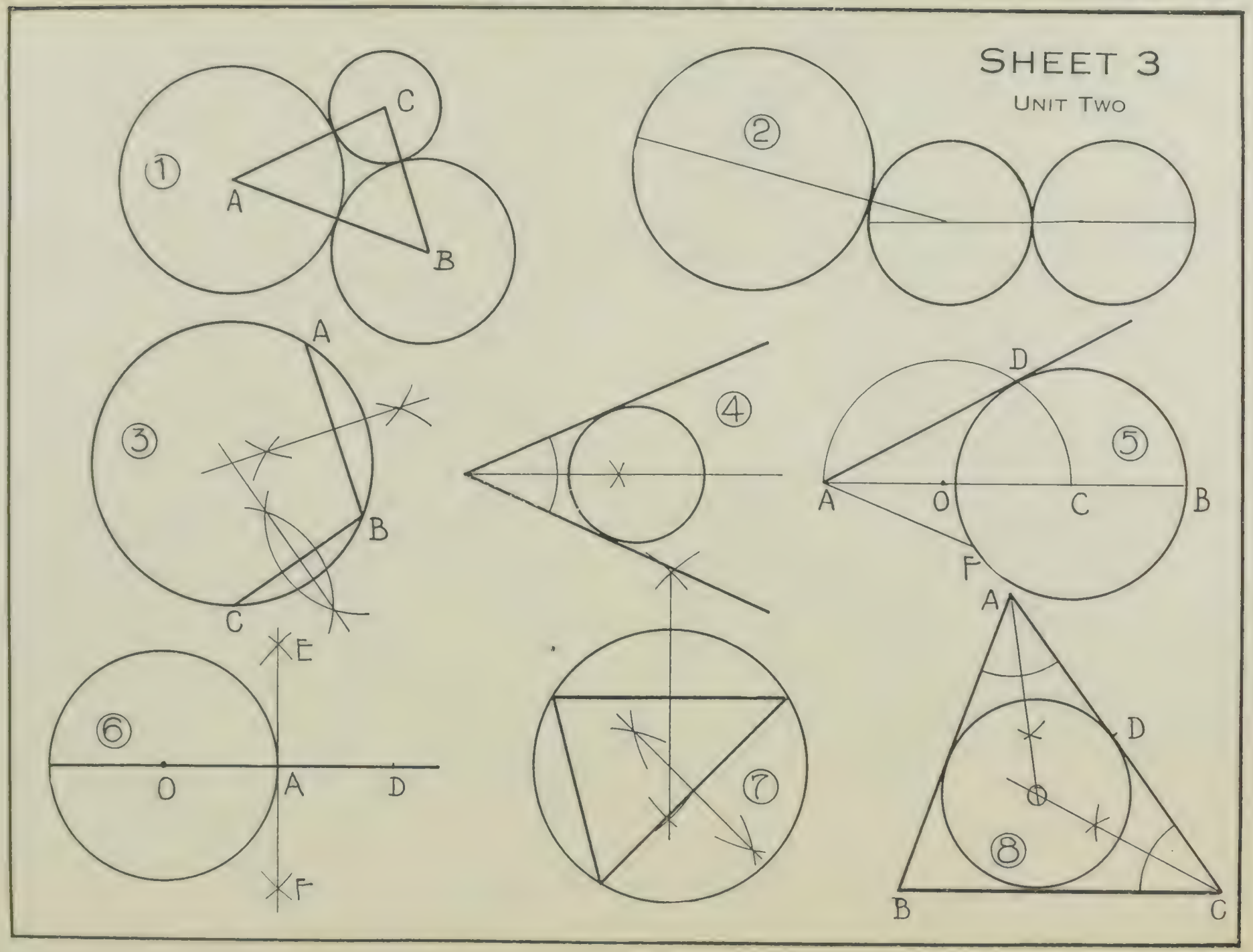
To describe a regular polygon on a line AB: Take a pentagon as the figure (Reference Sheet).

Produce AB its own length to D. On AD construct a semicircle. By trial with your compasses divide the semicircumference into 5 equal parts, marking the point 2. Join B2.

Put a circle through A, B, 2. Step off B2 around this circle, getting your pentagon.

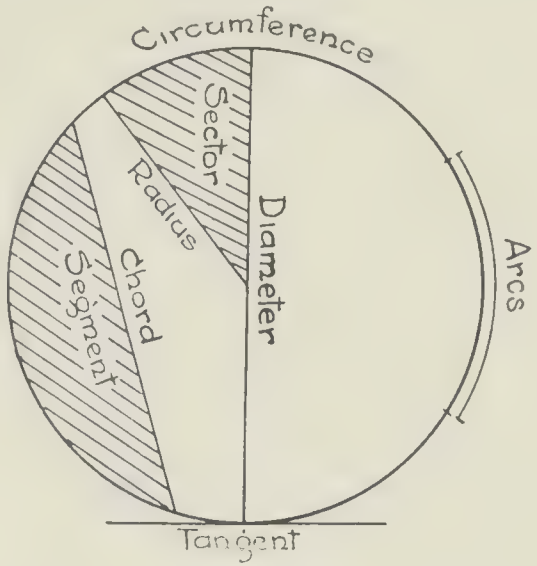
This and the previous problem call for accuracy. In either problem, no matter what the shape of the polygon, you must always use point 2.

There is a reason.


SHEET 3
UNIT TWO
1
A
B
C
2
3
A
B
C
4
5
D
A
O
C
B
F
6
E
O
A
D
F
7
8
A
D
O
B
C

SHEET 3—UNIT TWO. CIRCLES

This sheet deals with circles. The parts of a circle are all named in the accompanying diagram.



In Fig. 1 you have to make circles of radii 1⅛″, 1″ and ½″ to touch each other. Lay off AB equal to 1⅛″ +1″, and describe the circles. Take a radius of 1⅛″ +½″ and swing an arc from A. Take a radius of 1″+½″and swing an arc from B to cut the first arc at C. C is centre of last circle. Figure it out.

Fig. 1 shows any 3 circles touching in succession. The solution is evident.

Fig. 3 presents an important problem. You have to pass a circle through any 3 points as A, B, C. Join AB, BC. Bisect both. Where the bisectors meet is the centre of the circle. Can you figure it out?

If you joined AC, how could you state the problem?

Fig. 4 shows the method of putting any circle inside an angle. You will meet this problem later when you will put a circle of given size in an angle.

Fig. 5. To draw a tangent to a circle from a point anywhere outside. A tangent must just touch the circumference without cutting it, and if you join the tangent where it touches to the centre, you will get a right angle. Draw AB through the centre O. Bisect AC and put a semicircle on it which cuts the circle at D. Join AD and produce it. AD is the tangent. How do you know that the angle ADC is right? Is AF a tangent? How many tangents can you draw from A to the circle?

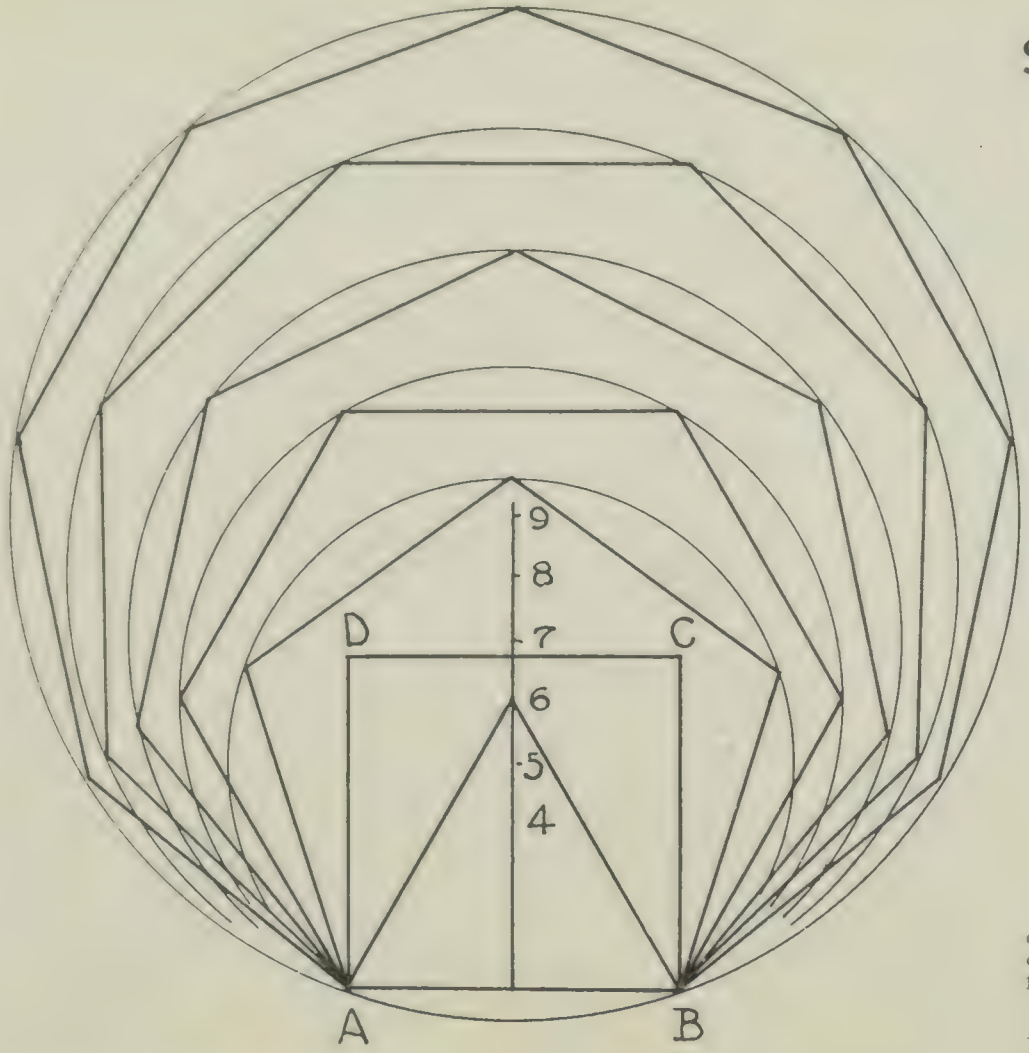
Fig. 6. At the point A on the circumference you have to draw a tangent. Join A to the centre O, and produce the line. Make AD equal to OA, and bisect the line OD. EF is the tangent.

Fig. 7. Put a circle around a triangle. You have done this already on this sheet.

Fig. 8. Put a circle inside triangle ABC. Bisect any two angles as A and C. The centre of the circle is where the bisectors meet. Join OB. What does it do to the angle B? If you joined OD, what is the size of the angle ADO?

Rules for 7 and 8: To put a circle outside a triangle, bisect the outside, i.e. the sides. To put a circle inside a triangle, bisect the inside, i.e. the angles.

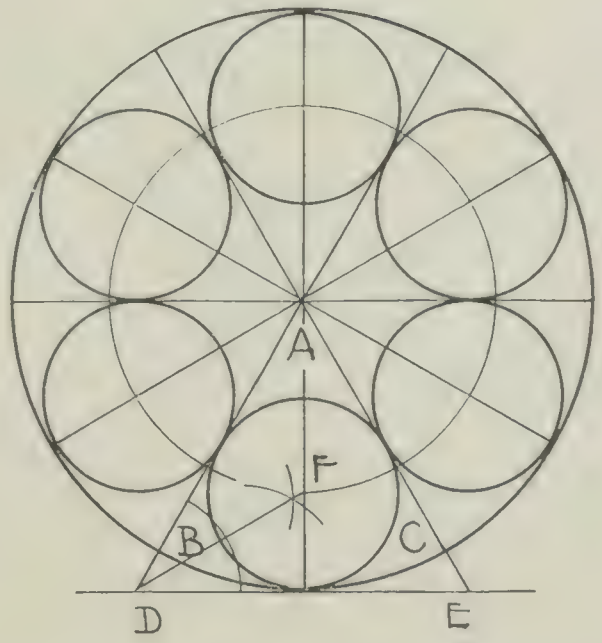
In this sheet use your judgment as to sizes and placing.



To put any regular figure on a line AB, 1½″: Make equilateral triangle AB6. Make the square ABCD and find its centre 4. Bisect 6 4 in 5. Take 5 6 and step it off the centre line as at 7, 8, 9. 5, 6, 7, 8, 9 are centres of circles which contain regular figures of 1½″ side. This is an unusual method and will try your accuracy. You will find out things about it.

SHEET 4

UNIT TWO



To put 6 equal circles in a circle of 4″ diameter, each circle to touch two circles and the larger circle: Step your radius 6 times around circumference. Draw diameter through these points.

Produce AB and AC to meet the tangent DE. You can see that the problem is to put a circle into a triangle ADE. When you have done this, swing the centre to cut your other middle lines, and swing your small circles.

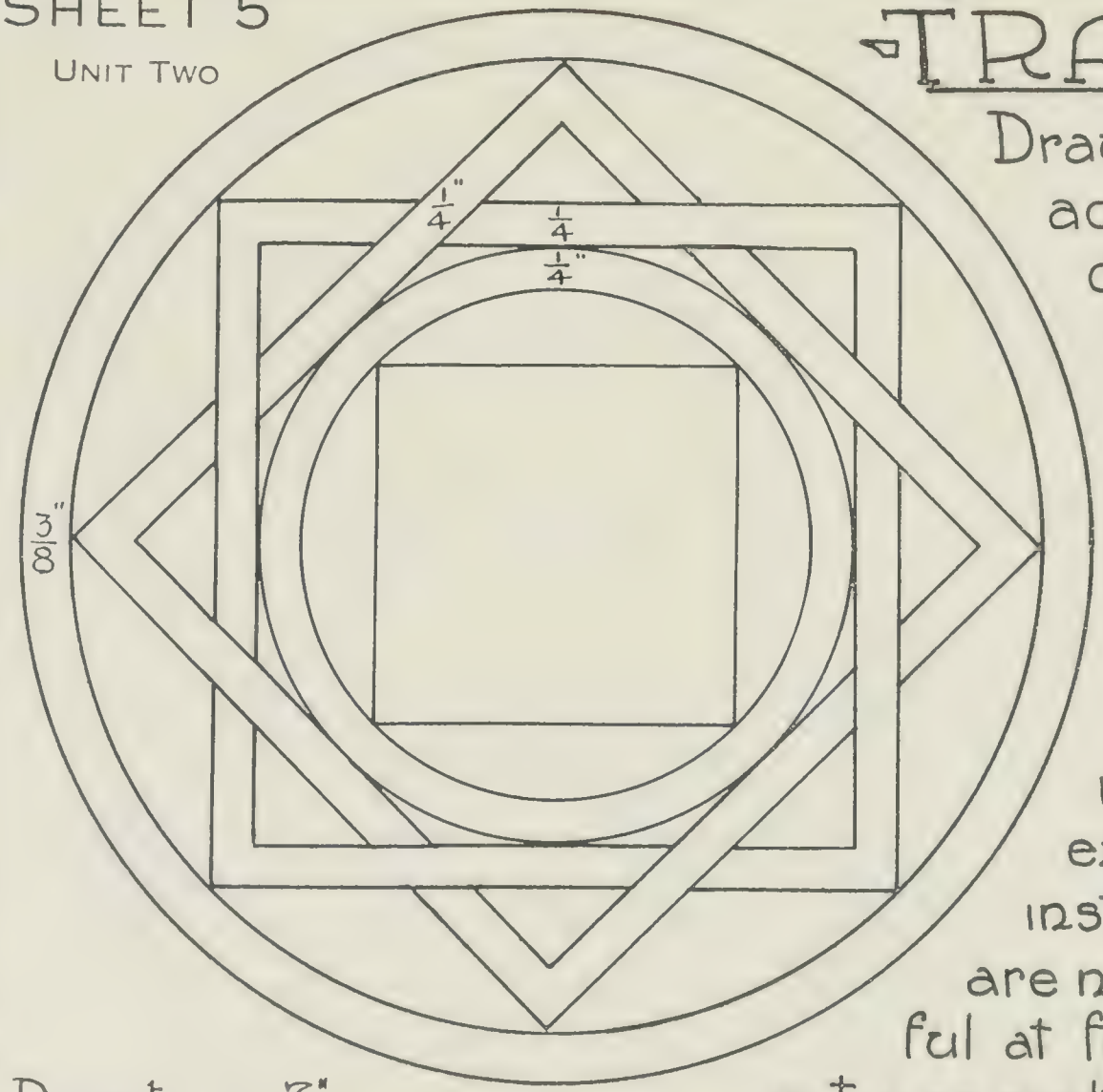
In both these problems you will experience difficulty, but if you are not satisfied with your work, do it again and again.

Up to this stage you have been doing exercises to make you careful, neat, and accurate. If you feel you are not, do not feel satisfied, but keep doing these exercises. You cannot build a sound house on a poor foundation.

SHEET 5

UNIT TWO

TRACERY



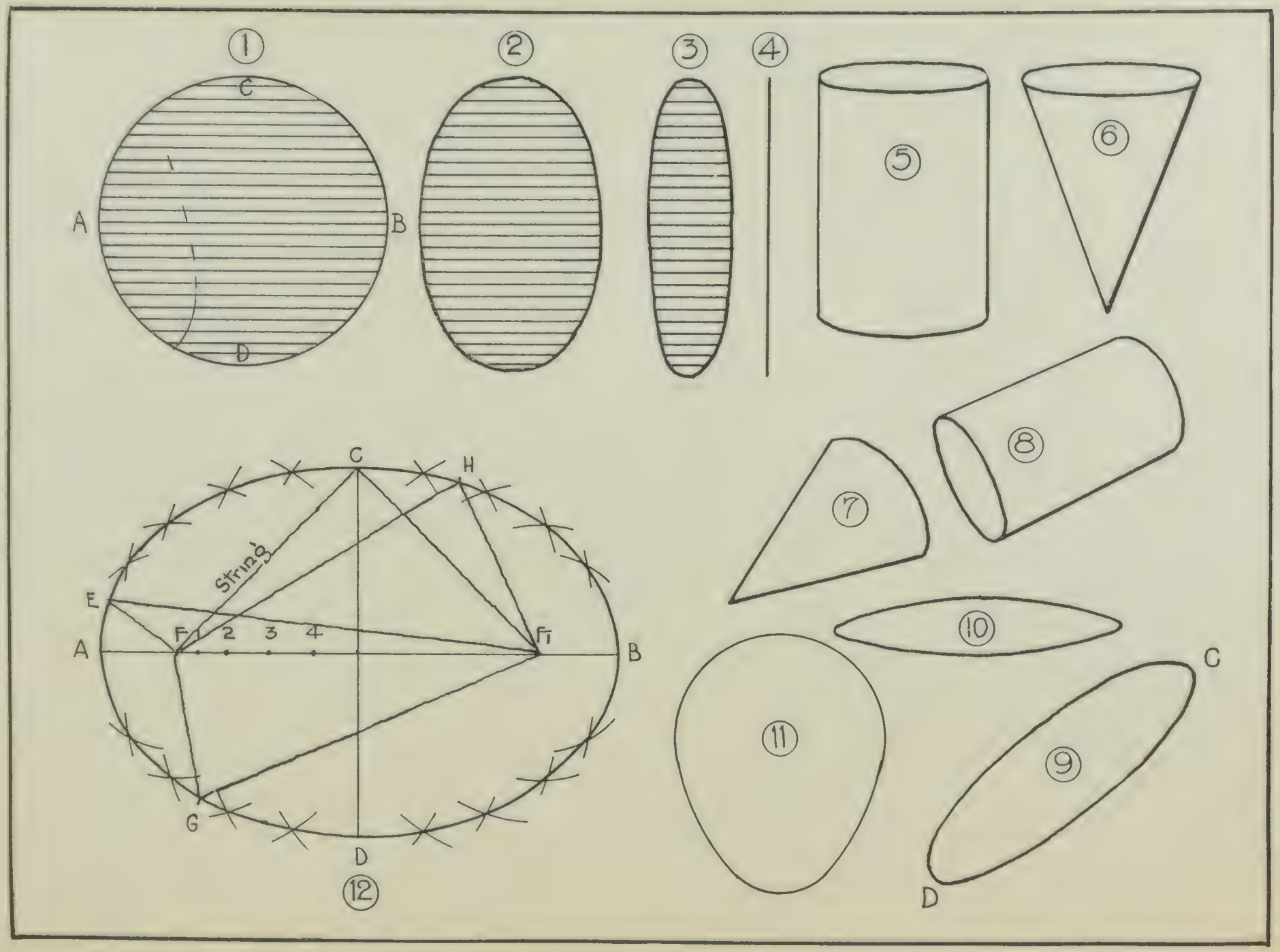
Draw this diagram according to these dimensions. You can test accuracy by making another circle inside the small square.

The purpose of this type of work is to afford you exercise in using instruments. If you are not very successful at first, do not permit yourself to be downcast.

Diameter is 7"

PROVINCIAL LIBRARY,
VICTORIA, B. C.

ELLIPSES—PRELIMINARY



ELLIPSES

You have now come to a very important lesson. Look at Fig. 1. This represents a full view of a coin held up before you. It is a circle with diameters AB and CD equal. Now twist it round, still keeping CD vertical. You have now Fig. 2, which is called an ellipse. An ellipse is simply a circle out of true. A funny change has taken place. No part of the circumference of Fig. 2, the ellipse, is circular. AB has become shortened. By shortening AB still further, you get the thin ellipse in Fig. 3, and by still shortening, you can lose AB altogether, and your original circle has disappeared into a line. Do it.

Figs. 5, 6, 7, 8, show the application of ellipses to drawings. Fig. 9 shows an ellipse whose CD is not vertical as in Fig. 2. Place your coin in this position. Fig. 10 shows a wrongly drawn ellipse. An ellipse has fully rounded corners, and is never sharp. Fig. 11 shows a true oval. An ellipse is often called an oval. It cannot be. Why so?

In Fig. 12 you have the drawing of an ellipse. AB and CD are not called diameters, but axes. The axis AB is the size of the original diameter, but CD has been shortened. Place your coin in the position. AB is called the major axis and CD the minor axis. Get three thumb tacks or pins. Take half the major axis and swing it from C to cut the major axis at F and F1. At C, F and F1 stick in your tacks, and tie your string round them. Take out the tack C, and in place of it put in the point of your pencil, and move your pencil around to the full extent of the string. You see what happens. You have described an ellipse. You will notice that you have two centres, F and F1. These are called foci. You will also notice that when you went around with your pencil inside the string, the combined distance of any point from the foci was always the same. Did you notice in this connection the position of the string when the pencil point reached A? If you did not, go around again and see.

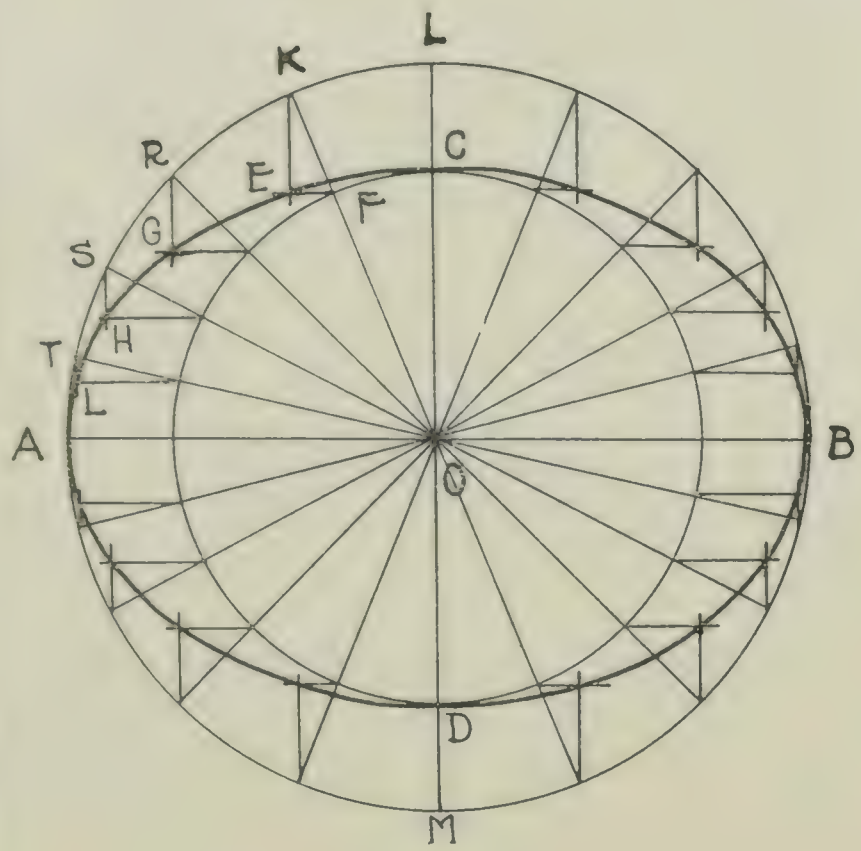
Measure the lengths of CF and CF1 and lay them out together as a straight line LW. Take any points on the curve as at E, G, H. Measure EF+EF1, GF+GF1, HF+HF1, and check up on LW. They must all total the same length.

There are quite a few ways of drawing an ellipse, and the method used to get Fig. 12 will be done by you in your next sheet.

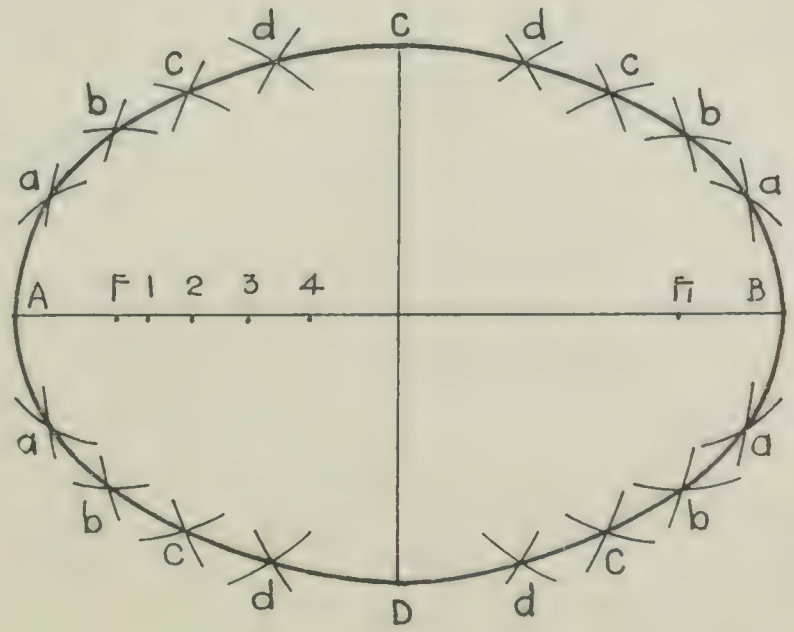
In drawing your freehand curve, do not spend too much time in getting a fine clean line. Rather sketch the line in, to get general direction. You will do the ellipses accurately with French curve and ink on later sheets.

SHEET 6

UNIT TWO



①



⑤

ELLIPSES

Fig. 1. Given the axes of an ellipse, to construct it. Let AB equal 5″ and CD equal 3½″.

Set the axes at right angles through their middle points. Think of the coin you used in last sheet. Set it up, first, full view, so that you see the circle LAMB. Now pull the circle down towards you so that the diameter LM becomes the minor axis CD, L falling directly on CD.

Take any points K, R, S, and T, on the original circumference. When you pulled down the circle, L came down at right angles to AB. Similarly, lines drawn from K, R, S, and T at right angles to AB will contain the new locations of K, R, S, and T on the curve of the ellipse.

Join KO, RO, SO, TO.

If you continued pulling the circle forward, K would at last settle on AB. Somewhere on this line going from K downwards, is the new location of K on the curve of the ellipse. From F draw a horizontal line FE to meet the perpendicular from K at right angles. This is the new position of K. Treat the points R and S and T similarly. Find their new locations at G, H, and L, and sketch through these points to get the quarter of your ellipse.

There are short cuts to get all the other points, but it would be advisable to find every point in the way shown above.

Fig. 2. Set up your axes AB and CD as in Fig. 1.

Take half the major axis CD in your compasses and with C as centre swing an arc to cut AB in F and F1, the two foci.

Set off any points as 1, 2, 3, 4 between F and the centre. Take A1 in your compasses and from centres F and F1 swing four arcs.

Take B1 in your compasses and from centres F and F1 swing arcs to cut the first arcs in a.

Take A2 in your compasses and swing as before.

Take B2 in your compasses and cut in b.

Take A3 and swing.

Cut with B3 to get c.

Take A4 and swing.

Cut with B4 to get d.

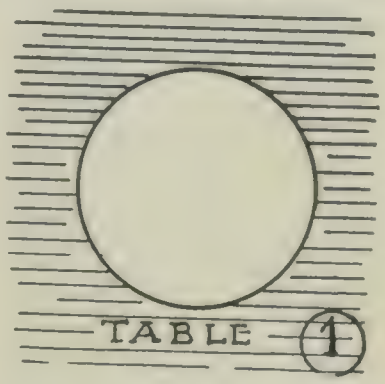
The points a, b, c, d, are on the ellipse. Sketch with your pencil through these points to get your complete ellipse.

This is the approved geometrical method.

It is necessary to know about ellipses before you go into the subject of projection.

PROJECTION

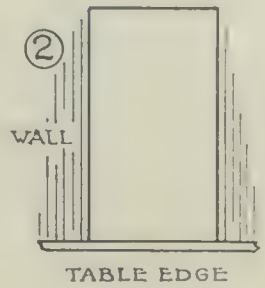
Up to this point you have been dealing with figures on the flat, or plane figures, but when you are asked to "draw" a solid object on paper, you must employ a different method. If you take a square pyramid, for instance, you could describe it fully by words, a long and tedious process. But you can describe it clearly and intelligibly by means of a drawing. Making an intelligible drawing of a solid object on a flat piece of paper is known as Descriptive Geometry. This is the only universal language in use at present, if you can call drawing a language. A Frenchman makes an accurate drawing of an object with full measurements. A Chinaman, without a knowledge of French, can take that drawing and "read" it. The Frenchman's thoughts, expressed by line on paper, have become intelligible to the Chinaman through Descriptive Geometry.



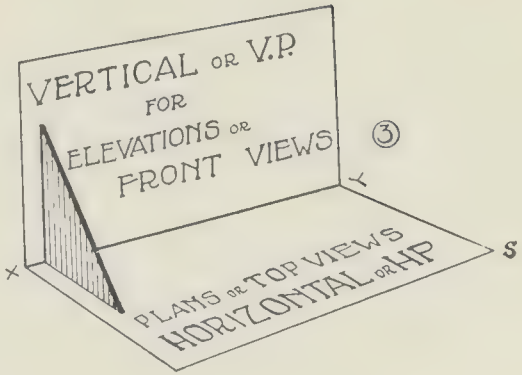
Do not imagine the subject is difficult. Take your time and reason out the early steps, but understand everything before passing on.

If you look down on a cylinder standing on its end you can draw a chalk mark around the edge of the circle. Remove the cylinder and you see a circle which is the amount of area covered by the end. This view is called a Top View or Plan. Fig. 1.

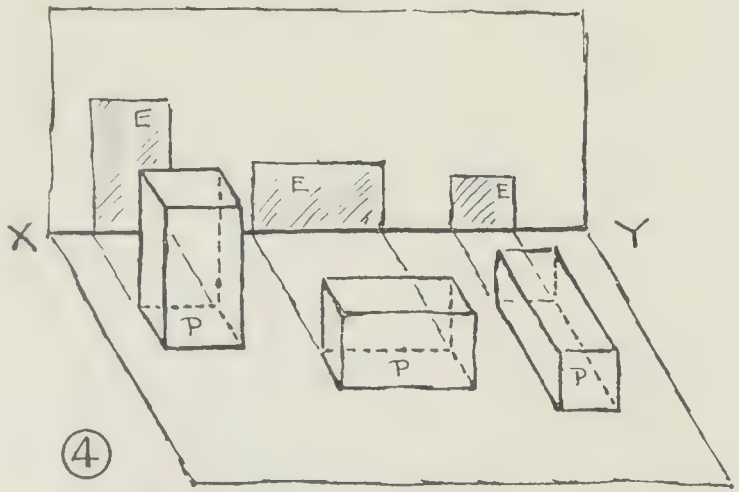
Stand the cylinder in the same position on a table which is against a wall. Push the cylinder against the wall and view it directly from front. You will see it blocks off a rectangle or oblong of area. This is known as an elevation or front view. Fig. 2.



The plan view was on the floor, which lies flat or horizontally, and the elevation view was on the wall, which is straight up-and-down or vertical. A flat surface is known as a Plane. Notice where the wall meets the ceiling. If both surfaces are plane, you should see an absolutely straight line. A straight line is the cutting of two planes. Find as many such straight lines in the room as you can. How many are on your drawing board? Draw a straight line on a sheet of paper. Is this actually a straight line? Take your sheet and fold it. Open it up partly. Now you have two planes instead of one. What do you see where they meet? Measure the width of what you see. Why is the straight line you drew with your pencil not really a line? At this stage write down carefully all you have found out so far in this lesson.



There are three types of planes, types of planes, (a) horizontal; (b) vertical or straight up-and-down; and (c) oblique or sloping. A horizontal plane is named H.P. A vertical plane is named V.P. An H.P. must always be at right angles to its V.P. If you set a square in the angle between a V.P. and an H.P. there should be a perfect fit. What is the number of degrees between the two planes? Open a book and set up the two planes, putting your square in the angle. Take a sheet of paper, fold it in the middle and then unfold it till you have your H.P. and V.P. You will notice the intersecting line. This line dividing the two planes is known universally as the XY line, just as x, y, z, are used universally in Algebra.



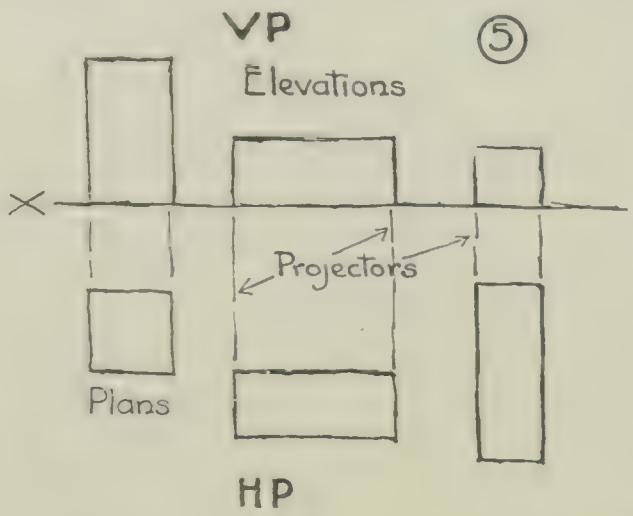
Take your paper and place carefully on it the different names you have learned so far. Then make a sketch as in Fig. 3.

Take your drawing board and set it up as a V.P. on a table, which is your H.P. Now make three rectangular prisms (Reference Sheet) out of soap, and place them as in sketch. Your top views or plans will all be rectangles. You can see this.

Now if you asked a carpenter to make you objects from these plans, he could not do so, as you had not given him full details. It is just the same as if a man said to you, "When I was going down the street today," and then said no more. Your plans so far are an incomplete sentence. You need your elevation to convey complete sense.

Place your eye on the level of the H.P. and sight each object forward to strike the back screen or V.P. Light travels in straight lines and each point will be shot back against the V.P. in a direct straight line, and each of the solids will block off the areas as shown on sketch. These areas are the elevations of your solids. Now you can take your table top and drawing board to the carpenter. He will be able to make the object, because now he can read your complete thought. But such a way of doing things is awkward and there is a better way.

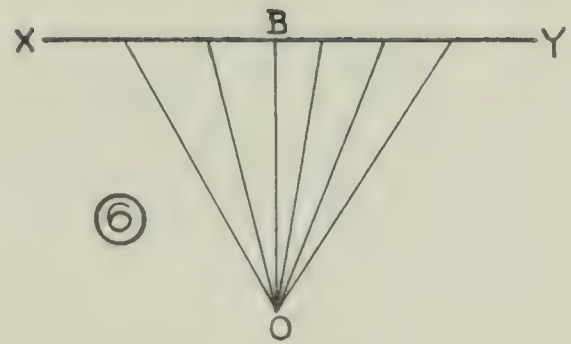
Take a sheet of paper and fold it in the middle. Lift the top half till you have your V.P. in the true position, and place your solids as before. Draw lines around the bottoms to get your plans, and roughly sketch lines on the H.P. to the V.P. to get the bottom of your elevations.



Try to keep the two planes at right angles. In the elevation heights will be the same as on the objects. Transfer these heights roughly, and remove your solids. Now lay down the V. P. flat again, and your drawing is completed.

This method is awkward and inaccurate, and being inaccurate is valueless. But you have learned something.

Take the sheet of paper you had difficulty in holding in position. It is now flat, and the only difference you can see between the V.P. and H.P. is the XY line. You have now an angle of 180° between the two planes instead of your real 90°. Fig. 5 shows the rough drawing you have just made. You will notice that the lines going from the plans to the XY are roughly at right angles to it. These



lines are called "Projectors." They are lines showing the shortest distances from your plan points to the XY. Look at Fig. 6. Of all the lines drawn from O to XY, OB is the shortest. Do this on a piece of paper and measure the angle made by your shortest line. You should find it to be 90°.

A projector then is a line drawn at right angles to an XY line. At this point you need a drawing board and a T-square. Many books demand that a board be quite square and that a T-square be always 90°. But you can get along nicely with a board that is not square and and a T-square that is not at 90°. All you need is a straight edge on your board.

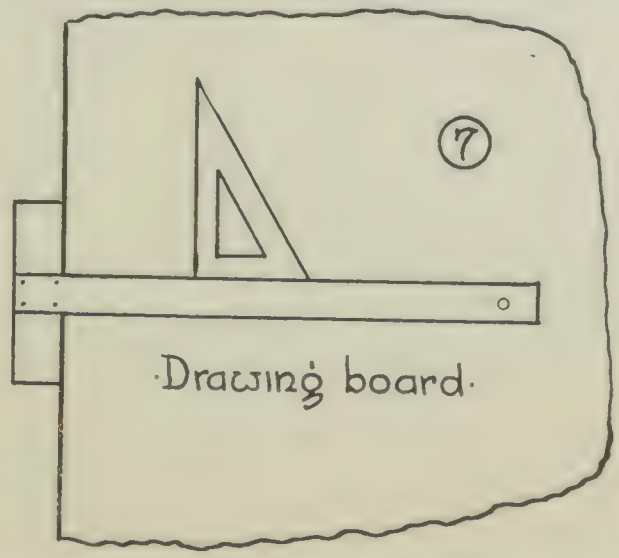
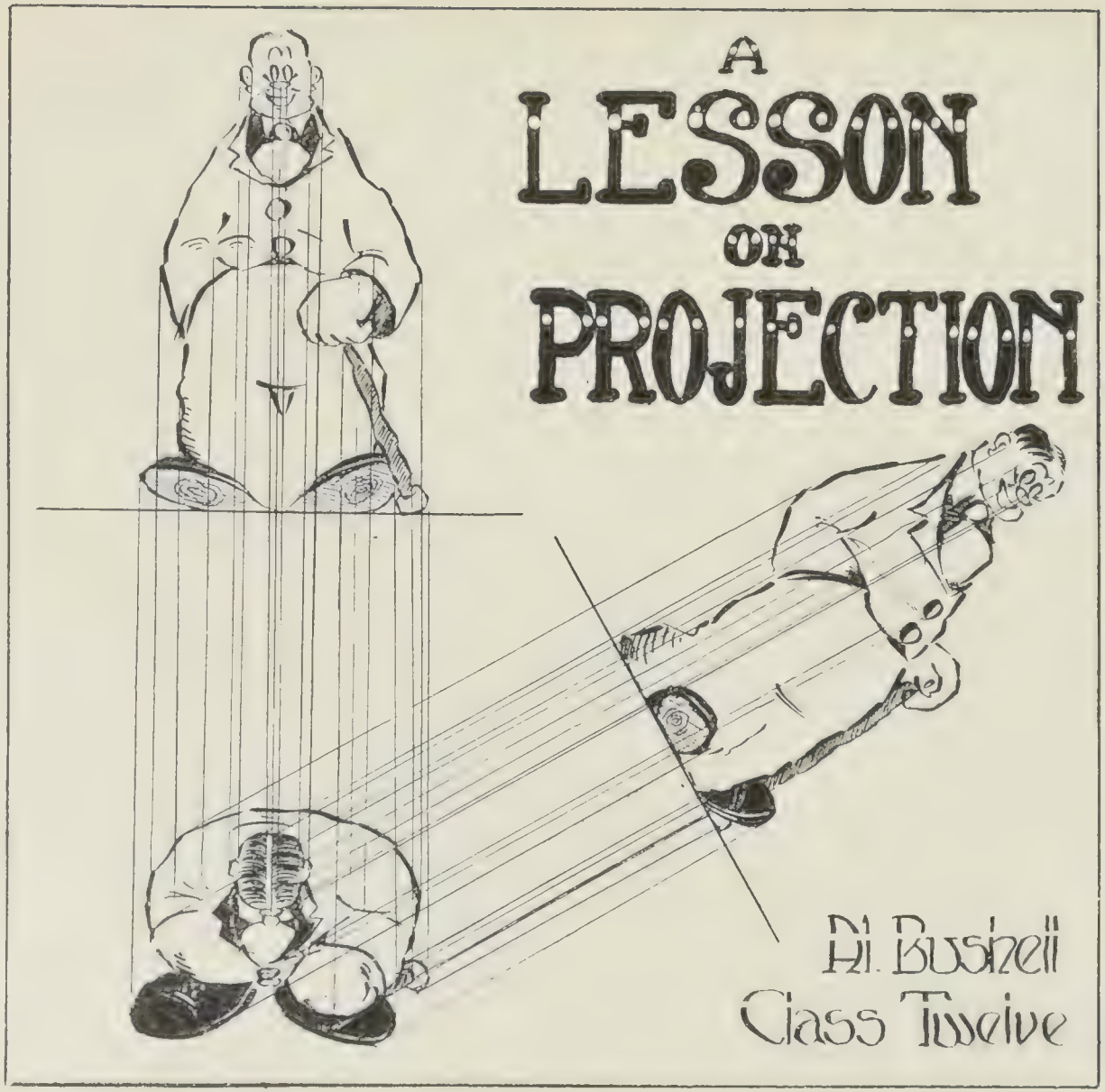
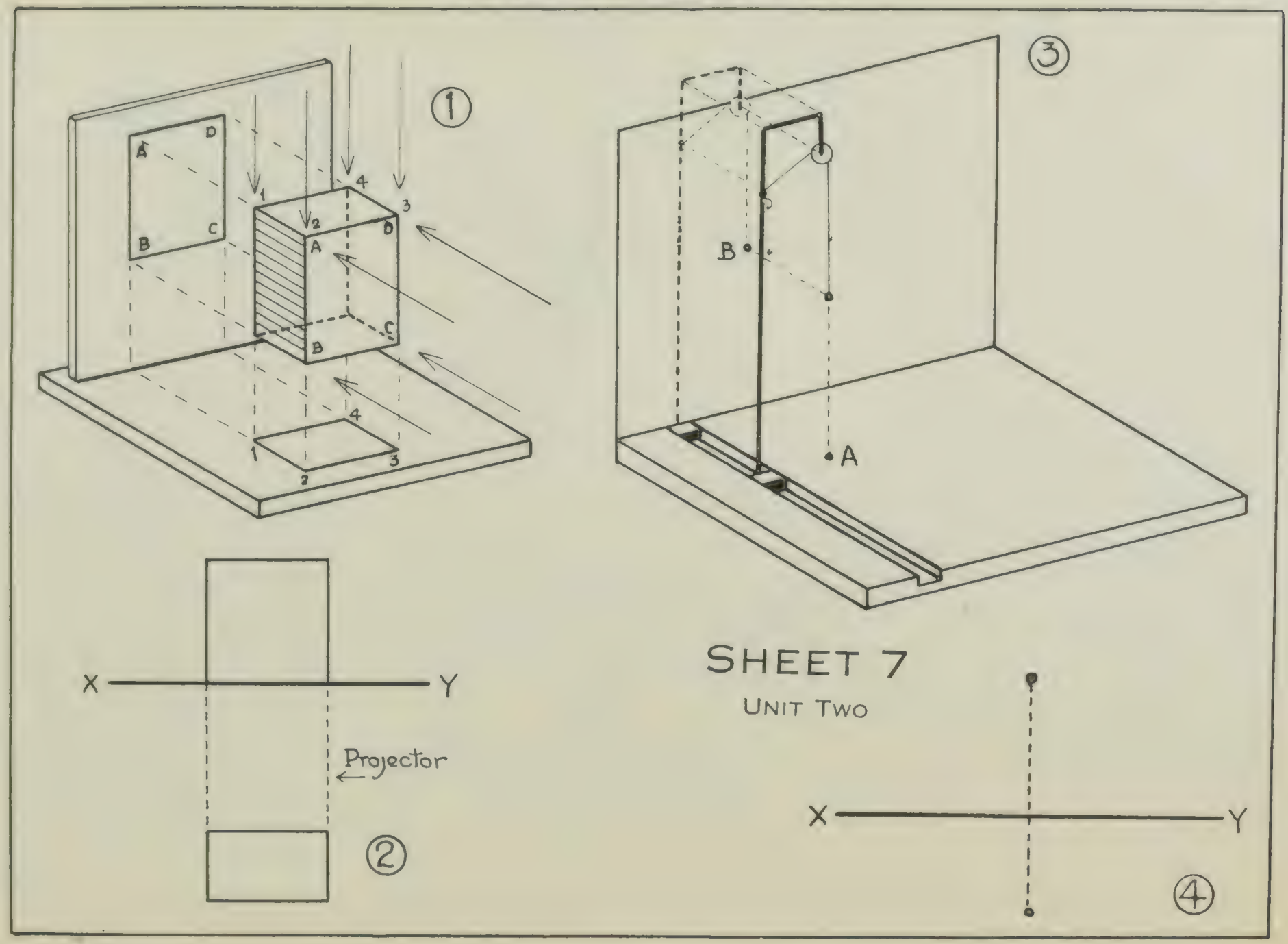


Fig. 7 illustrates the method of using a T-square and board.



This drawing, done by a boy, illustrates the principles of Projection. It looks funny, but there is a lot in it, and later on you will come back to study it.

SHEET 7—UNIT TWO



At this stage you need a drawing board and T-square.

Fig. 1 represents a pictorial view of a rectangular prism suspended in the air. It is above the H.P. and in front of the V.P. By looking down along the arrows you get your plan 1 2 3 4 on the H.P., and by looking at it from the front along the arrows you get the elevation ABCD on the V.P.

Fig. 2 gives a true readable description of this solid.

Now follow carefully. As was said before, geometry deals with the placing of points. This solid has 8 different points or corners. Suppose you took the point 2, and removed all the rest of the solid, 2 would be still suspended and in the original position. You could imagine it to be a lead pellet, Fig. 3, suspended on a string from a support, the support running in a groove in your H.P., and cut at right angles to the V.P. This groove, of course, would be a projector to the V.P. Imagine a small pulley suspended from the support, the twine passing through this pulley.

Now suppose the pellet to be 3″ above the H.P. By means of your pulley raise or lower the pellet till you have it at 3″ above the H.P. Tie your twine to the support. How many positions, 3″ above the H.P., can the pellet have? But the pellet has also to be 2″ away from the V.P. Slide your support in the groove until you have the pellet 2″ away from the V.P. You have located your point.

Now release your twine till the pellet drops to the H.P. Mark the point, as it is the plan of your point. Pull it up again to its proper location. Push your support back in the groove until support and pellet touch the V.P. Mark the position of the pellet, which is the elevation of your point. A is the plan, B is the elevation of the point given.

Fig. 4 shows a true readable description of the position of the point in the sketch in Fig. 3.

This is practically all the theory you have to learn about Projection. Boys have been known to call Projection "chasing the points." There is a great deal of truth in this statement, as you will find out.

Care must be exercised in ruling along a tee square that the pencil is held in the proper position. The pencil should be held in a nearly vertical position and pulled, not pushed, from left to right. This position ensures that the sharp point of the pencil makes a clean line. Too much slope in the pencil does not give a clean line. When you begin to use ink, you will learn making correct lines mostly by making mistakes, but if you practise careful work beforehand with your pencil, the ink work will be done with fewer blunders.

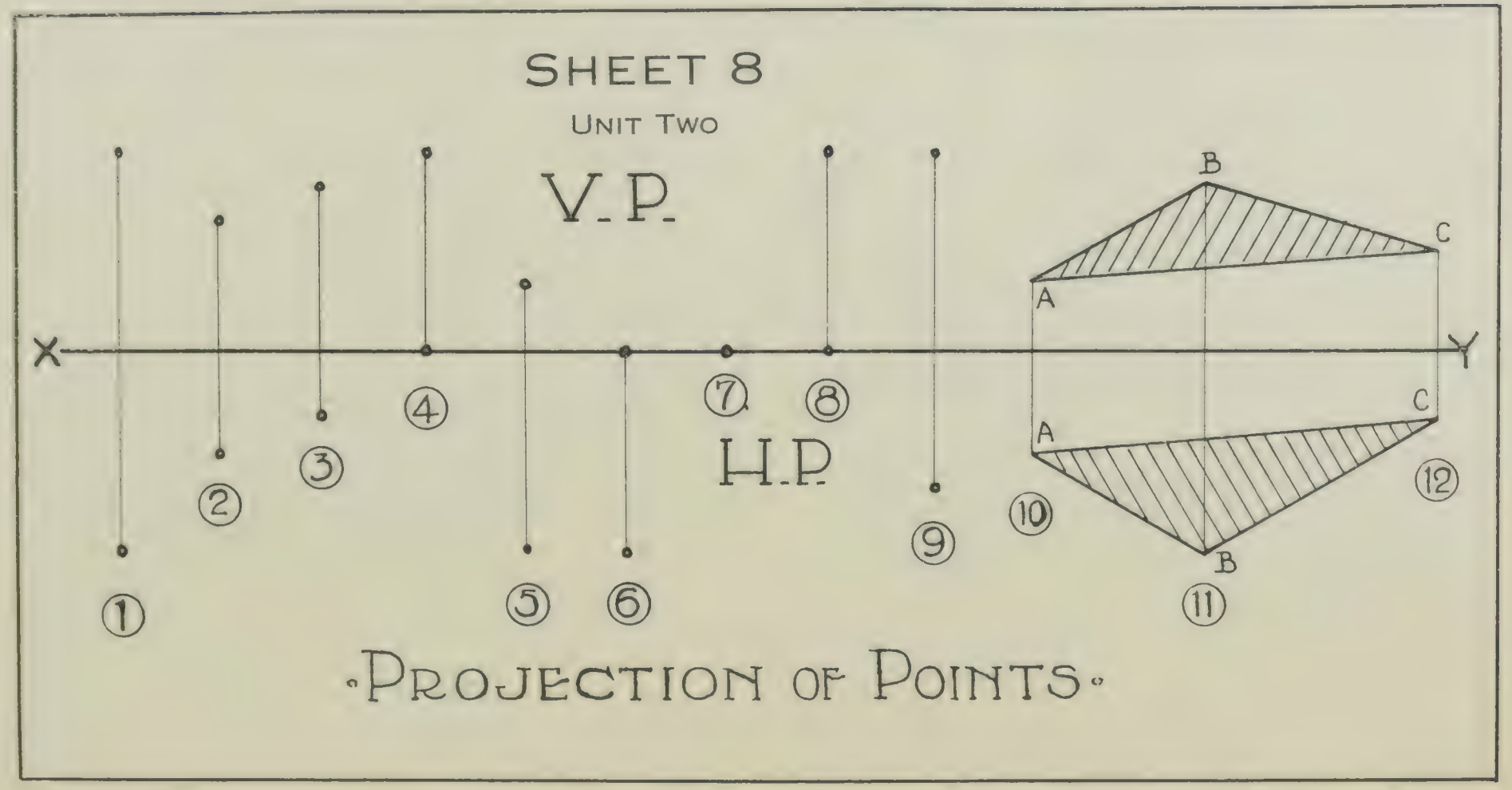
In the two lessons on Projection the projector lines were put in as dotted lines. This is correct usage, but as good dotted lines are difficult to make and take too much time in the making, in all following sheets projectors will appear as light construction lines.

Scaffolding is put up around a building during erection. But when the building is completed, the scaffolding is removed. Your projector lines are the scaffolding of the figures you erect. In many cases a finished drawing has all the projectors erased. In student drawings, generally the projectors are left in for purposes of checking by the instructor.

At this stage you must have found out that it does not pay to work with indifferent instruments and poor pencils. Complete and satisfactory drafting sets can be obtained from $5.00 up, and a pair of celluloid squares from $1.00 up. The matter of pencils is important. A cheap low-grade pencil can never give a satisfactory line. There are excellent goods such as El Dorado, Venus, Castell, Royal Sovereign, Kohinoor, with little to choose between them. They are consistent in texture, and you may depend on them. You should have an "H" and an "H.B".

PROVINCIAL LIBRARY, VICTORIA, B.C.

SHEET 8—UNIT TWO



PROJECTION OF POINTS

This is a very important sheet, and it would be advisable to make a little apparatus as in Fig. 3 on last sheet. A small wooden block as base, into which is stuck a piece of stove wire, is all that is necessary. Leave an eye in the end of the wire for your string to go through. Actually locating your points first with this simple apparatus will help you to visualize. A good draftsman who thoroughly understands his work, must be able to "see" a problem, just as you can recall in your mind's eye an incident that has happened. Before any invention was ever made, it originated in the brain as a thought. It was visualized, and the thoughts were then arranged on paper as drawings. When you have placed your point in Fig. 1, and before you locate it on paper, shut your eyes and try to picture it in the actual position you have placed it.

Now draw these points:

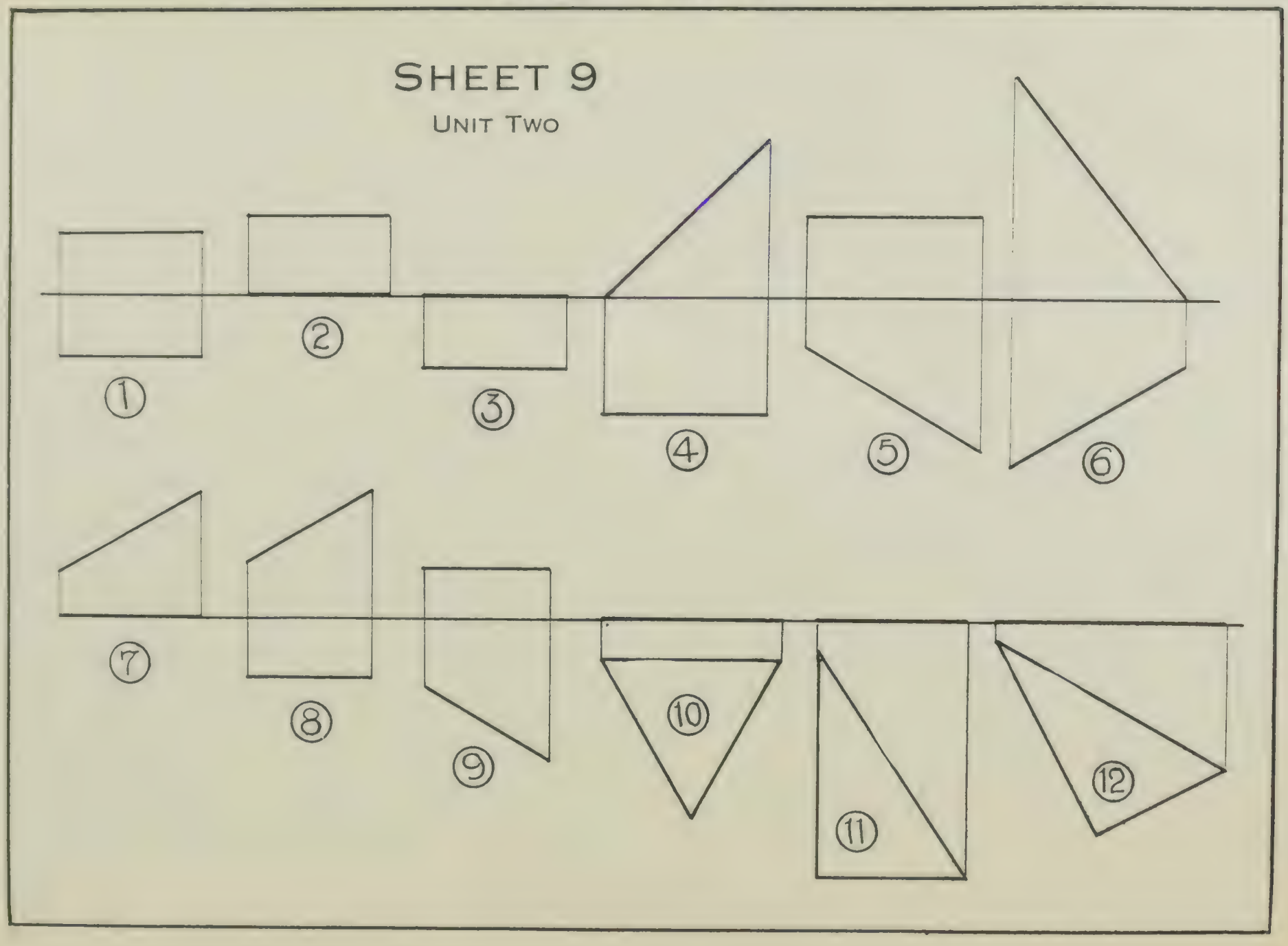
Location.

1. 3″ above H.P.; 3″ in front of V.P.
2. 2½″ above H.P.; 2″ in front of V.P.
3. 2¾″ above H.P.; 1″ in front of V.P.
4. 3″ above H.P.; the point is on the V.P.
5. 1″ above H.P.; 3″ in front of V.P.
6. On the H.P.; 3″ in front of V.P.
7. On the H.P.; on the V.P.
8. 3″ above H.P.; on the V.P.
9. 3″ above H.P.; 2″ in front of V.P.
10. 1″ above H.P.; 1½″ in front of V.P.
11. 2¼″ above H.P.; 2½″ in front of V.P.
12. 1½″ above H.P.; 1″ in front of V.P.

Join A and B in 10 and 11. You have now the plan and elevation of the line AB. Similarly you get the plan and elevation of the line BC. By joining AC, you have now the plan and elevation of the triangle ABC.

First you located a point. Then you located two adjacent points, which you joined, getting a straight line, which is the shortest distance between two points. Then you located three points, and by joining them, located a triangle.

It seems quite simple, but be sure you know the lesson thoroughly before proceeding.


SHEET 9
UNIT TWO
1
2
3
4
5
6
7
8
9
10
11
12

PROJECTING LINES

In doing this sheet provide yourself with two books or anything suitable to represent your two planes, and use matches for your lines. Place your match in the required position first, before making your drawing.

1. A line is 1¼″ long, is parallel to the H.P. and ¾″ above it; is parallel to the V.P. and ¾″ in front of it. If you take a book ¾″ thick, and place it on the H.P. and then place your match on the book, the match is everywhere ¾″ above the H.P., and is so parallel to it. It has an infinite number of such positions, but only one certain position is asked for. Shift your match around until it is parallel to the V.P. Then move it, still parallel, until it is ¾″ away from the V.P. Fig. 1 shows the drawing.

2. A line 1¼″ long is 1″ above the H.P. and parallel to it. It is on the V.P. Place your match in the position required and then draw.

3. A line is 1¼″ long, is on the H.P., and 1″ in front of the V.P. and parallel to the V.P.

4. A line 2″ long is parallel to the V.P. and 1½″ away from it. One end rests on the H.P. and the line makes an angle of 30° with the H.P.

5. A line 2″ long is parallel to the H.P. and 1″ above it. It makes an angle of 30° with the V.P. and the point nearest to the V.P. is ½″ away from it.

6. A line whose apparent length in elevation is 2½″, has one end resting on the H.P., and rises 2″ high. In plan the end nearest to the V.P. is ¾″ away, and the apparent length of this plan is 1¾″. This question is of a slightly different type from the preceding questions, but can be reasoned out.

7. A line of 1¼″ lies against the V.P., makes an angle of 30° with the H.P. and the lower end is 1″ above the H.P.

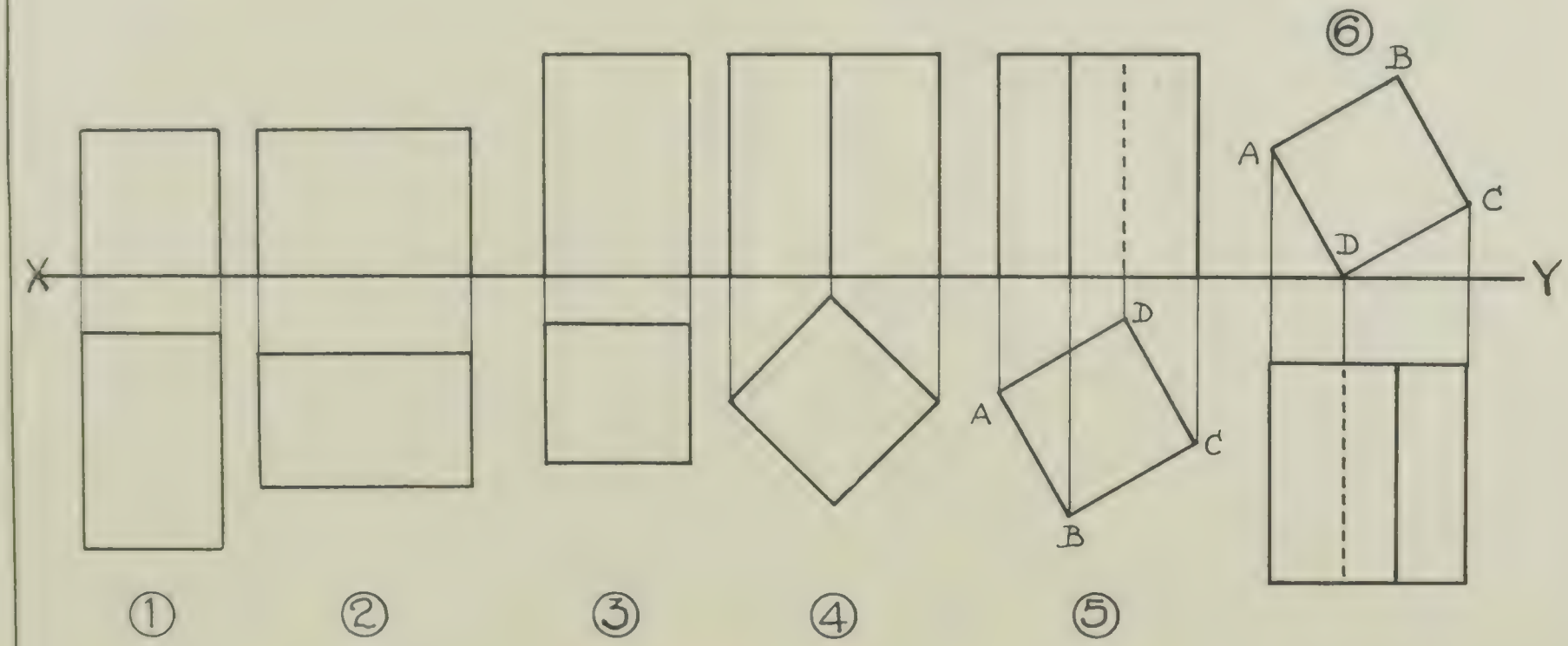
8. A line of 1¼″ is parallel to the V.P., makes the same angle in the same position as in Fig. 7, and is 1″ away from the V.P.

9. A line of 1¼″ is parallel to the H.P. and 1″ above it. Its nearest point to the V.P. is 1¼″ away, and the line makes an angle to 30° with the V.P.

10, 11, 12 represent triangles all lying on the H.P. Their elevation will be all on the XY. All points actually lying on the H.P. have their elevations on the XY line.

SHEET 10

UNIT TWO



PROJECTION OF SQUARE PRISM 1"×1"×1½"

PROJECTION OF SQUARE PRISM

A regular prism is a solid with rectangular faces, and regular figures as ends. (Reference Sheet.)

In dealing with this sheet you will have to follow carefully the written description of the position of each solid.

Fig. 1 shows the prism (a) resting on the H.P., on its face; (b) the end is parallel to the V.P. and ½″ away.

Fig. 2. The prism rests (a) on the H.P., on a face; (b) the end is at right angles to the XY; (c) the prism is ¾″ away from the V.P. Do you know of any other solid that you can place like this? Is this drawing a complete reading of a square prism?

Fig. 3. The prism (a) stands on its end; (b) a face is parallel to the V.P., and is ⅜″ away.

Fig. 4. The prism (a) stands on its end; (b) its faces make equal angles with the V.P.; (c), the nearest point in plan, is ¼″ away from XY.

Fig. 5. The prism (a) stands on its end; one face makes 30° with the V.P.; (c), the nearest point, is ½″ from XY.

You proceed as in the last case, but you notice you have a dotted line in this drawing that you did not have in Fig. 4. You can see the lines A, B, C, thrown against the V.P., but you cannot see D. But its elevation must be shown. Therefore its location is shown by a dotted line. Why did you not have a dotted line in Fig. 4 to represent the elevation of D?

Fig. 6 differs from the preceding questions in that you are given the elevation first. In projection you may get either the plans or elevations to start off with. This prism (a) is balanced on a long edge; (b) one face is inclined to the H.P. at an angle of 30°; (c) it is ¾″ away from XY.

(Are you using an actual prism as a model? If not, you are not getting the actual practice in placing the prisms in the required position. It is easy to make a wooden prism 1″x1″x1½″. If it can not be done, make a smaller model in soap.)

Now take your model prism and insert the 30° angle of your set square under a face to balance it.

Throw down your points to the XY, and extend to locate the plan. You will notice you have another hidden line.

In connection with this lesson, you will find that most of the difficulty is removed if you have the actual models. Their use in connection with a model V.P. and H.P. helps you to visualize positions better.

UNIT TWO EXERCISES

CONSTRUCTION OF REGULAR FIGURES.

1. Following principles in Sheet 2, inside a 5″ circle place a regular hexagon. Check up by stepping the radius around the circumference.
2. Do as in Question 1, and then bisect the necessary arc to get a duodecagon, which is another name for a twelve-sided figure.
3. On a 2″ line describe a regular nonagon, which has nine sides. How many degrees of arc are opposite each side?
4. Make a regular decagon, ten sides, on a 2″ line. There are two methods.

CIRCULAR WORK.

5. Take circles of 1″, 1½″, 2″ and 2½″ diameter, and make them touch in this order. Join the centres in order, getting a quadrilateral. Join the diagonals of this figure. What size is the angle at the intersection?
6. Take circles of 1½″ and 2″ diameter, ¾″ apart. Draw a line between them to touch each circle. As you know, this touching line is called a tangent. Connect your centres to the points of contact. How do these lines lie?
7. Take circles of 1½″ and 2″ diameter, and let them touch. From a point outside draw two tangents to touch both circles. Measure the lengths of these tangents and compare.
8. Find the centre of a circle—
   a. by using compasses;
   b. by using a set square, without compasses;
   c. by using a ruler only.
9. Draw any quadrilateral and put two circles inside, each to touch two sides and a diagonal.

POINTS.

10. Locate the following points:—
    a. On the V.P. and 2″ in front of it.
    b. On the H.P. and 2″ in front of V.P.
    c. 2″ above H.P., and ½″ from V.P.
    d. 1½″ above H.P., and on the V.P.
    e. On the H.P., and also on the V.P.

LINES.

11. a. A line of 2″ length in elevation lies on the V.P. It makes an angle of 45° with H.P.
    b. A line in plan appears as 2″, and is inclined to XY at 30°. Its height is 1½″. Show plan and elevation.
    c. A line of 2″ is parallel to H.P. and appears as 1½″ in elevation. Show.
    d. A line appears as 1½″ in elevation and is parallel to H.P. It makes 30° with V.P. Show.
    e. A line, one end resting on the H.P., appears as 2″ in elevation, and the apparent angle is 75°. Its plan makes an angle of 45° with V.P. Show by a diagram.

TRIANGLES.

12. a. A triangle ABC, with AB=2″, AC=2½″, BC=3″, lies flat on H.P., and with BC parallel to XY. You raise the angle A so that the triangle now makes 30° with H.P. Show elevation.

b. The same triangle stands vertically on BC, and BC lies at 45° to XY. Show plan and elevation.

At this stage the above two problems are hard, but if you make the triangle out of cardboard, and sit down to study the positions, you will probably succeed.

PRISMS. SHEET 10.

13. a. In Fig. 1 tip up the elevation so that face makes an angle of 45° with H.P. Show plan. How does it differ from plan in Fig. 6?

b. In Fig. 2 tip on the end until the under face makes 45° with H.P. Show plan.

c. In Fig. 3 tip elevation till the end makes 60° with XY. Show elevation.

d. In Fig. 2 twist the plan so that a face makes 60° with XY. Show elevation.

e. Place the plan of Fig. 1 on top of plan of Fig. 2 and show elevation.

f. Place plan of Fig. 6 on top of plan of Fig. 5 and show elevation.

g. Place plan of Fig. 3 on top of elevation of Fig. 5 and show plan.

TRACERY.

14. a. Take a rectangle 3″x6″, and put a straight line design inside.

b. Take a 6″ circle and put a circular design inside.

15. Take a 6″ side equilateral triangle and put three equal circles inside, each to touch two sides and two circles.

16. Take a 6″ side equilateral triangle and put three equal circles inside, each to touch one side and two circles.

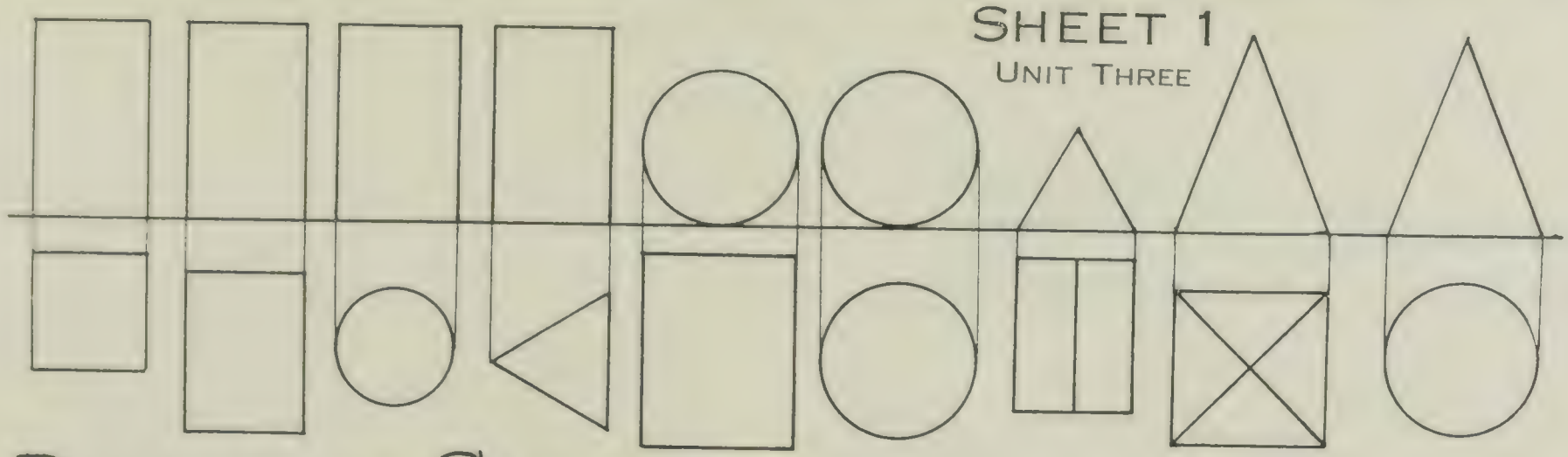
17. Take a 2″ side hexagon, and put six equal circles inside, each to touch two sides and two circles.

18. Take a 2″ side hexagon, and put six equal circles inside, each to touch one side and two circles.

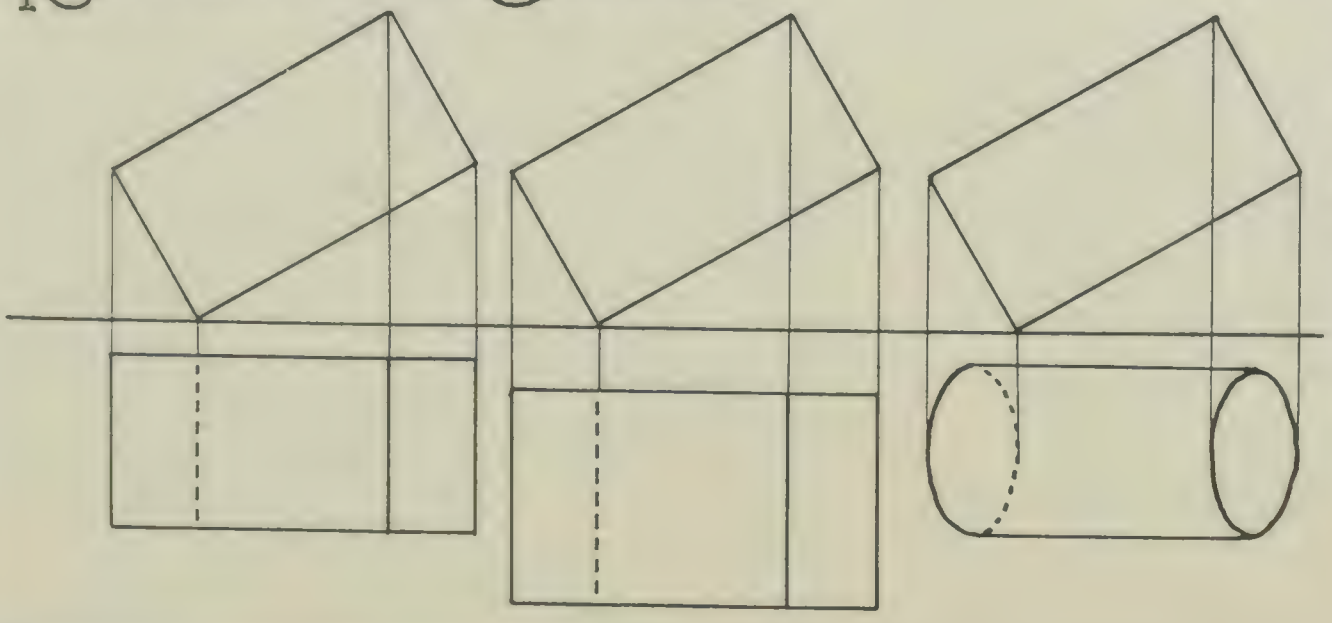
GENERAL.

19. A donkey is tethered by a swivel to a line 30′ long, anchored at both ends. The length of the tether to his head is 10′. Show by a diagram how much grass he can crop.

20. A table is 3′6″ by 8′6″. A fly crawls from a point 2′3″ from one corner on the end to a point 1′6″ from the opposite corner on the other end. Show his path by a scale diagram, and give the approximate length in feet and inches.



REFERENCE SHEET.



Copy this sheet.
The elevations are drawn first.
Solids may have the same elevations, but may differ in plan.
Elevation-"As I came to School" - - - - -
Plans-"I saw a man."
"I lost all my books."
"I forgot the way."

NAME THE SOLIDS

ABCDEFGHIJKLMNOPQRST
UVWXYZ 1234567890&—
abcdefghijklmnopqrstuv
wxyz. A gateway was made in
each side of the square, and the
space within the fortifications was
divided into four sections by wide
streets running between the op-
posite gateways. The men's quar-
ters and the tent or hut of the boys'
had definite positions within the
camp. A space about one hundred
feet in width was left open all a-
round the inner side of the rampart,

W. Chu. Class 16.

ABCDEFGHIJKLMNOPQRSTU
VWXYZ
1234567890&
abcdefghijklmnopqrstuvwxyz.

PERILS OF THINKING

A centipede was happy quite,
Until a frog in fun
Said, "Pray, which leg comes after which?"
This raised her mind to such a pitch,
She lay distracted in the ditch
Considering how to run.

Anonymous

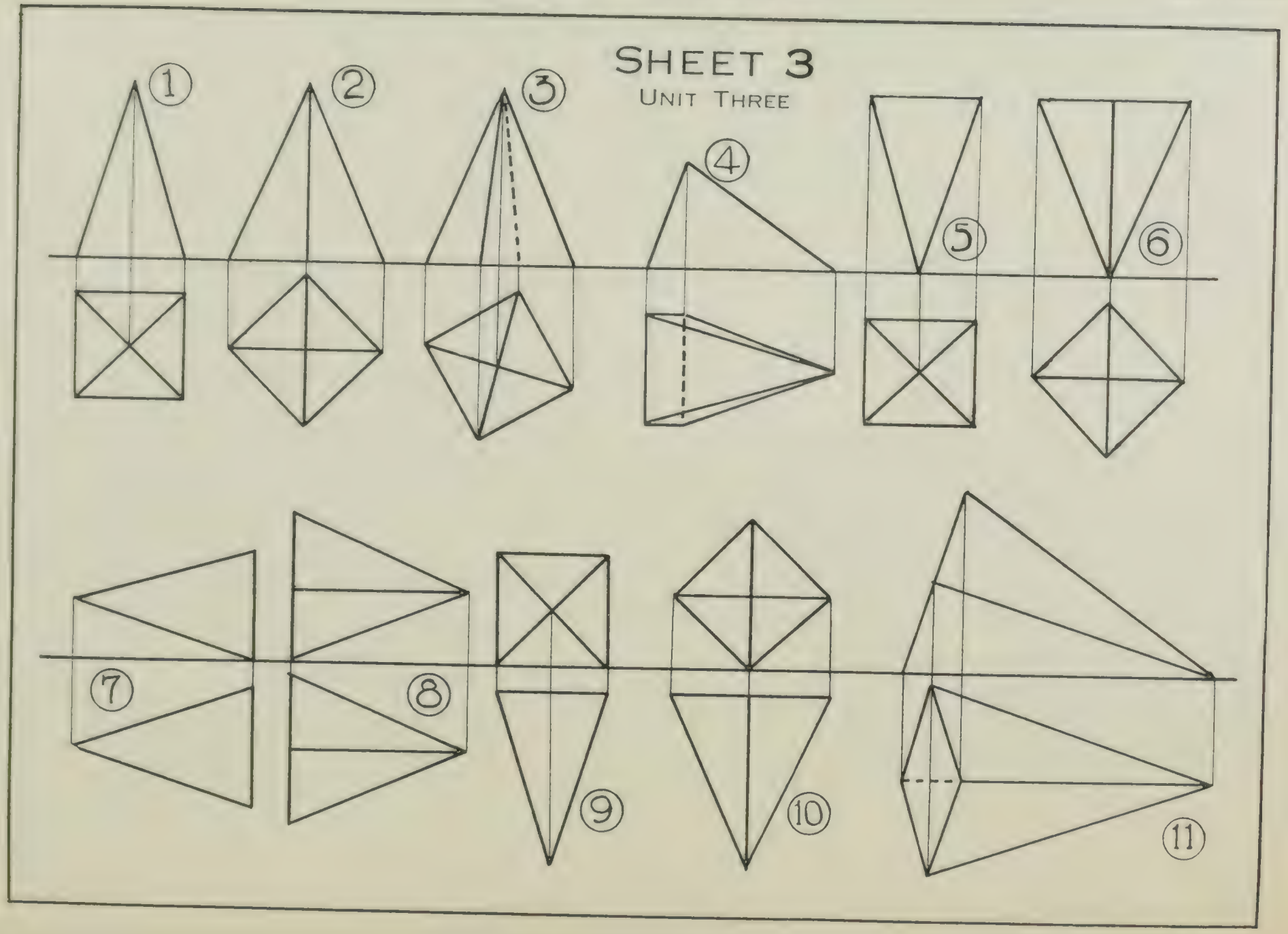
J. Moore Class 9.

SHEET 2
UNIT THREE

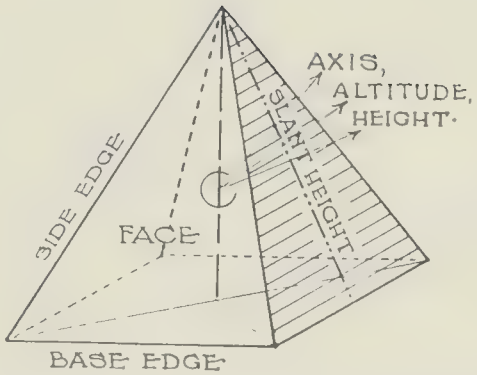
The sheets above show the progress in lettering made by two boys. They have now developed a style of their own

You should now be at the stage of not being content with doing simple lower case. On 6"x 9" paper, do both sheets.

PROVINCIAL LIBRARY,
VICTORIA, B. C.


SHEET 3
UNIT THREE
1
2
3
4
5
6
7
8
9
10
11

PYRAMIDS



Learn all the parts of the square pyramid from the sketch. Notice the difference between the height and slant height.

Before doing the page get a small model pyramid.

From the following descriptions first place your model and then make the drawing.

The pyramid is 1″×1″×1½″ high.

1. Resting on its base on H.P., with one base edge parallel to XY and ⅜″ away.

2. Resting on its base on H.P., with a base edge at 45° to XY. Why is middle line in the elevation hard, and not light as in Fig. 1?

3. Same position, but with a base edge at 60° to V.P.

4. Lying on a face, with its axis parallel to XY.

5. Poised on its apex, with a base edge perpendicular to V.P., and the end horizontal.

6. Same position, but with a base edge at 45° to V.P.

There are two mistakes in the first six problems. With the help of your model you should be able to find them.

7. Shows the pyramid poised on its base edge, which is at right angles to V.P., and with its base vertical.

8. Here the pyramid is poised on a corner, and its base is vertical. The bottom base edges makes equal angles with the H.P.

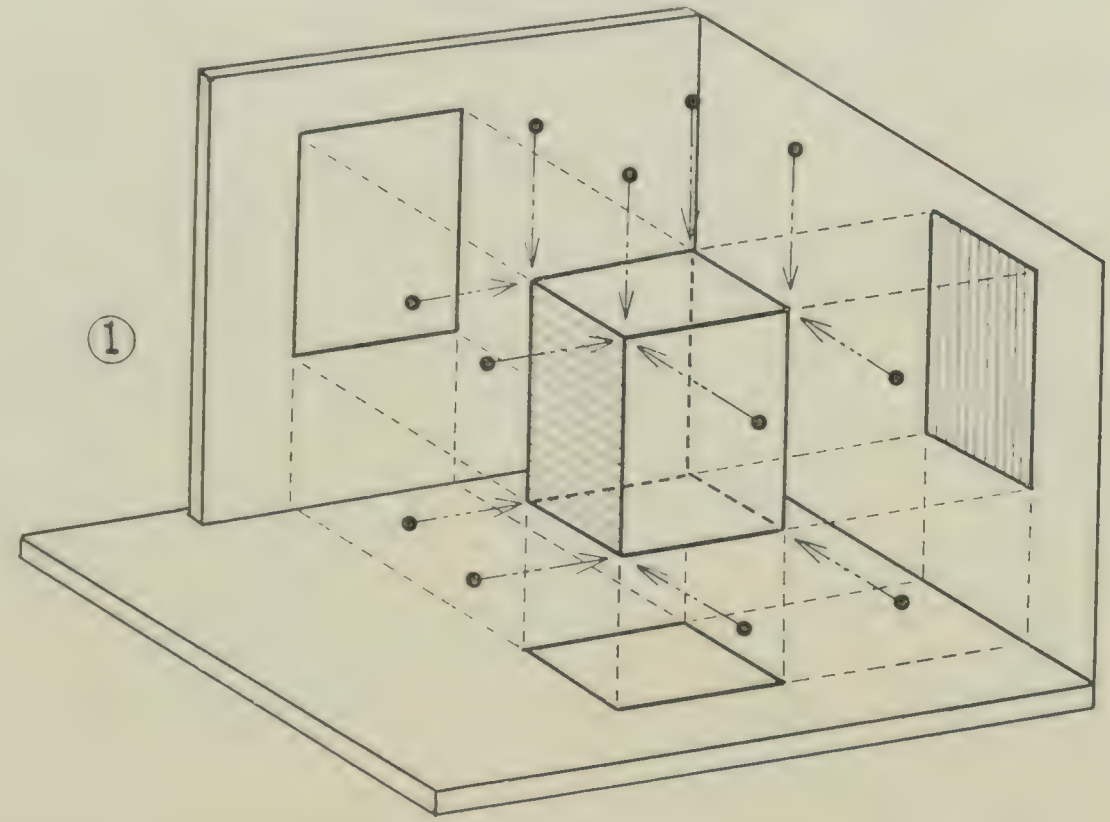
9. This is the same problem as 7, but the base is parallel to V.P.

10. This is the same problem as 8, but with its axis perpendicular to V.P.

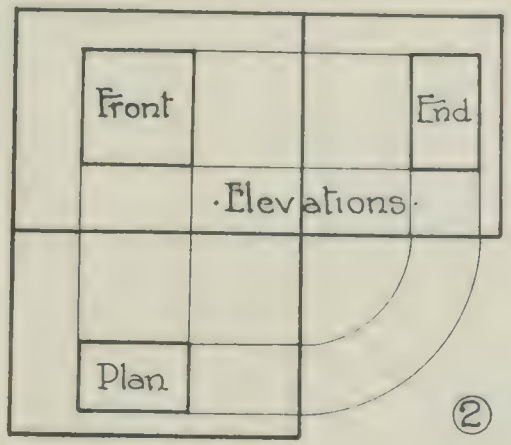
11. Shows a pyramid resting on the H.P. on a long edge. Its under faces make 45° to H.P. Can you figure out this problem?

So far you have dealt with only one elevation, the Front Elevation. But there are two others called the End Elevations. Such views are necessary in most drawings.

In Fig. 1 you are now familiar with the projections from the front view and plan. Add a new plane at the right side of the model. This is the End Elevation Plane. Sight the prism from the left along the arrows, and you project the shaded face of the prism onto the new elevation plane, getting the shaded figure as indicated.



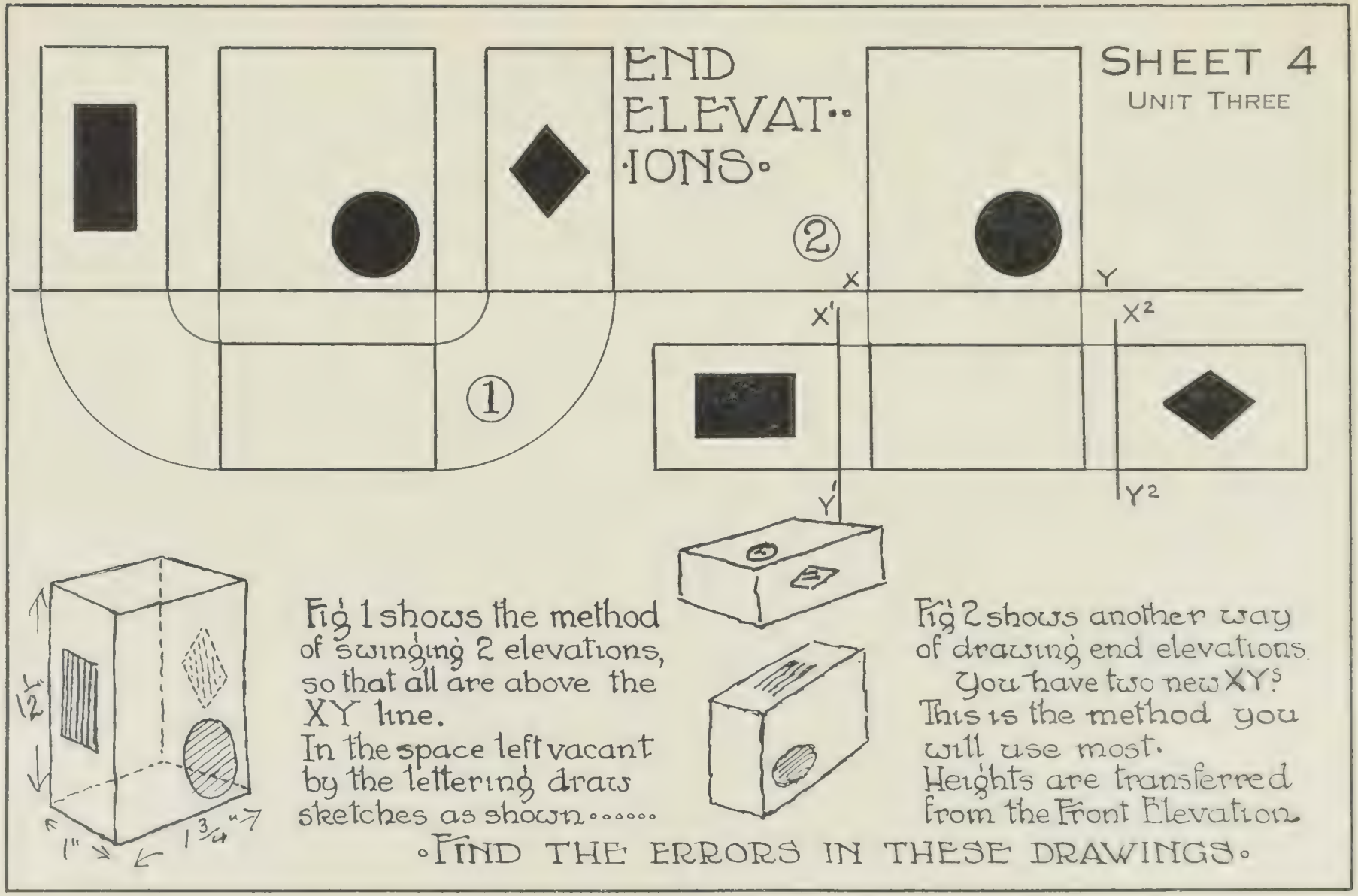
①



②

In Fig. 2 these three planes are all laid flat, the two V.P.s alongside each other. The method of getting projectors from the H.P. to the new V.P. should be plain to you.

There is another method of getting the end view, which you will use later.

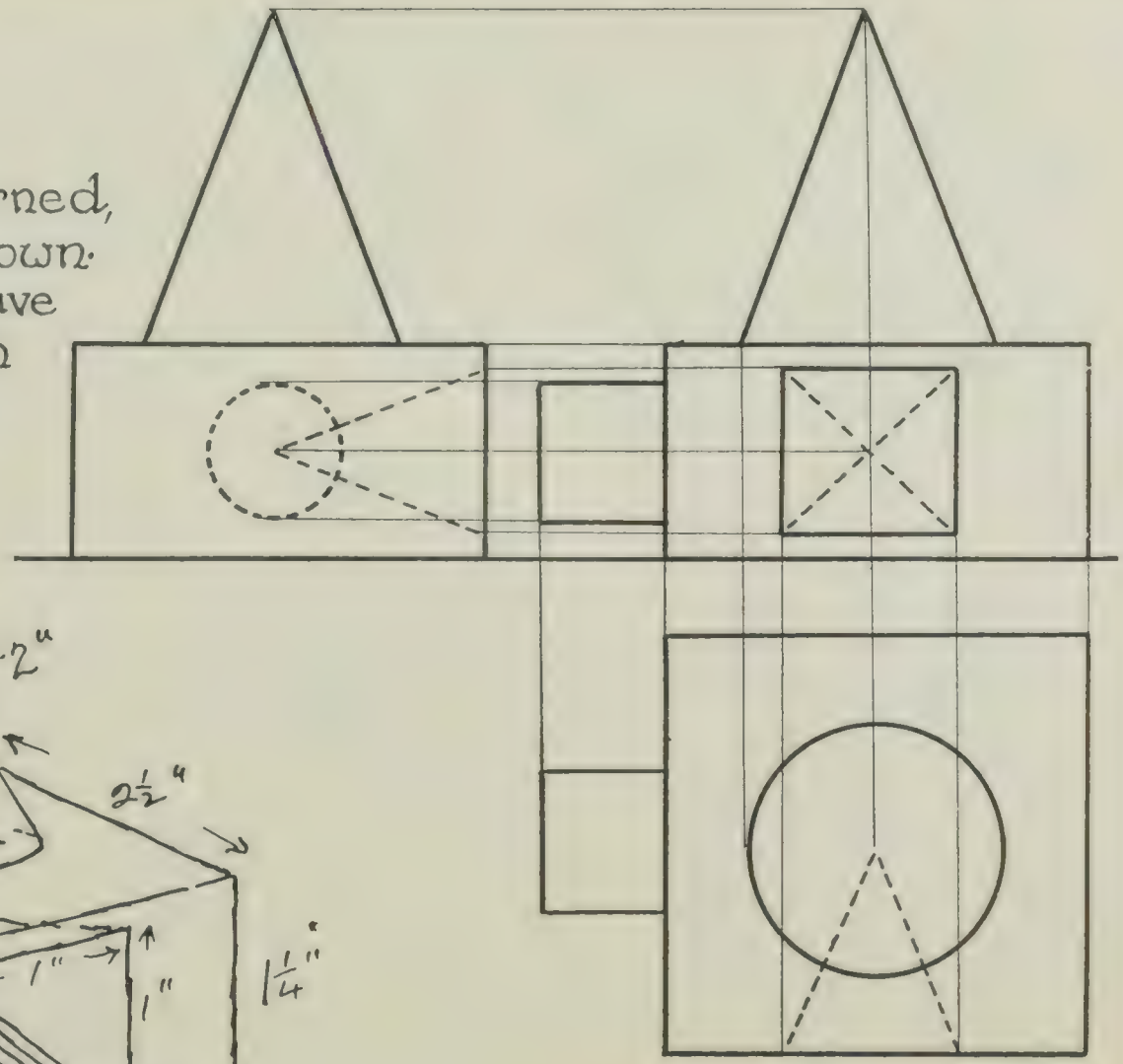

END
ELEVAT··
·IONS·
SHEET 4
UNIT THREE
②
①
X
Y
X'
X²
Y'
Y²
1½"
1"
1¾"
Fig 1 shows the method of swinging 2 elevations, so that all are above the XY line.
In the space left vacant by the lettering draw sketches as shown·····
Fig 2 shows another way of drawing end elevations.
You have two new XYs
This is the method you will use most.
Heights are transferred from the Front Elevation
·FIND THE ERRORS IN THESE DRAWINGS·

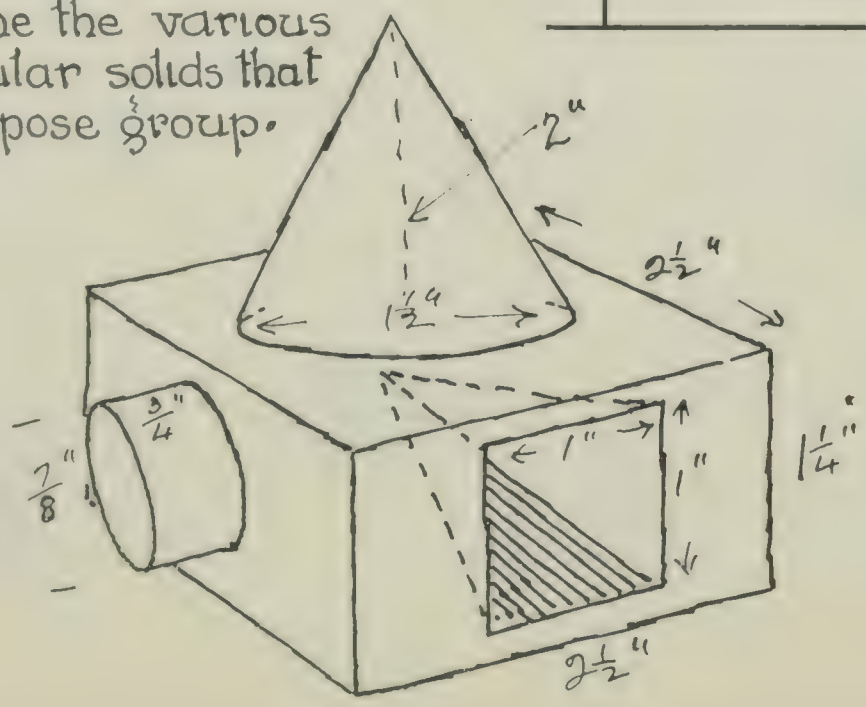
SHEET 5

UNIT THREE

From what you have learned, make the drawings as shown. Find the error. When you have done above, copy the sketch below freehand, making it larger, and leaving out dimensions.

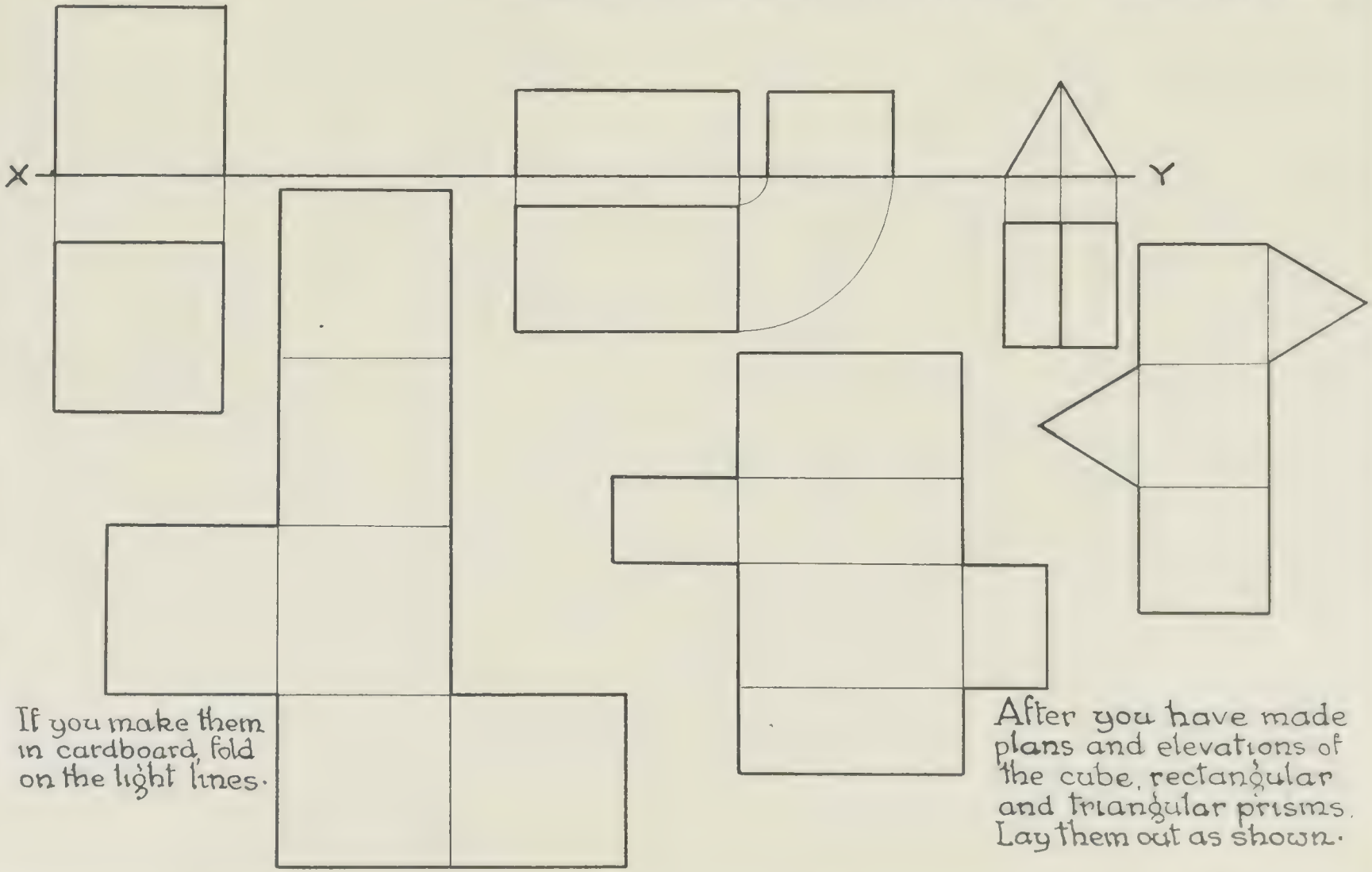
Name the various regular solids that compose group.





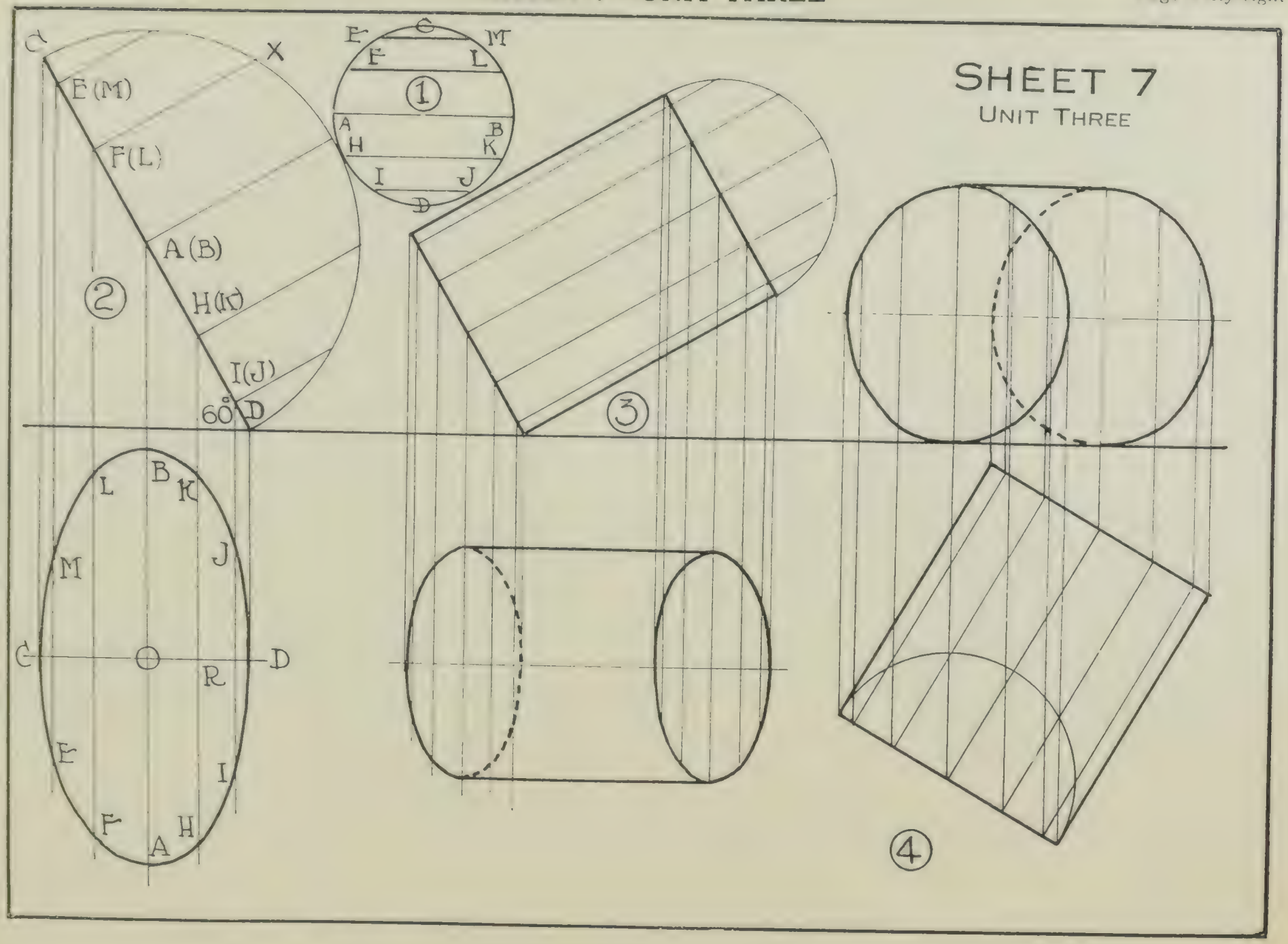
SHEET 6
UNIT THREE

·DEVELOPMENT OF SOLIDS·



If you make them in cardboard, fold on the light lines.

After you have made plans and elevations of the cube, rectangular and triangular prisms, Lay them out as shown.


SHEET 7
UNIT THREE
C
X
E (M)
F (L)
A (B)
H (K)
I (J)
60°
D
②
E
C
M
F
L
①
A
B
H
K
I
J
D
③
L
B
K
M
J
C
O
D
R
E
I
F
H
A
④

CYLINDERS

In Sheet 6, Unit 2, you were shown two ways to draw ellipses. In this sheet you will find ellipses in actual drawings.

If you take Fig. 1 you will find horizontal lines drawn through opposite 30°. These lines are called location lines. You will meet them often. They are the lines that direct you in chasing points.

If you pull the point C down, you have changed the circle into an ellipse. Notice very carefully, however, that though you have shortened CD, you have not shortened the horizontal lines. Cut a circle out of cardboard and draw these lines. Keep this model, as you will need it.

AB and all the other location lines run horizontally. When a letter is put in brackets thus, (B), it means that B is directly behind a point in front and cannot be seen. Your circle here in elevation is shown as a line. Now if you look down on top of the circle you will get the plan. You will notice that the diameter CD has become shortened, but all the location lines are their original size.

Throw down the different points to the plan. Locate AB on H.P. any distance from the XY. Draw CD perpendicular to AB through middle point O. If you measure OB you will find that it is half of the real diameter in the elevation.

Place the cardboard circle as in Fig. 2. Put a semicircle on AB and find your 30° points. From these points drop perpendiculars on AB. What you have done here is simply to show one-half of a full view of the circle with its location lines. In the other half the location lines are exactly similar to those in the first half, because they all originate in your 30° points.

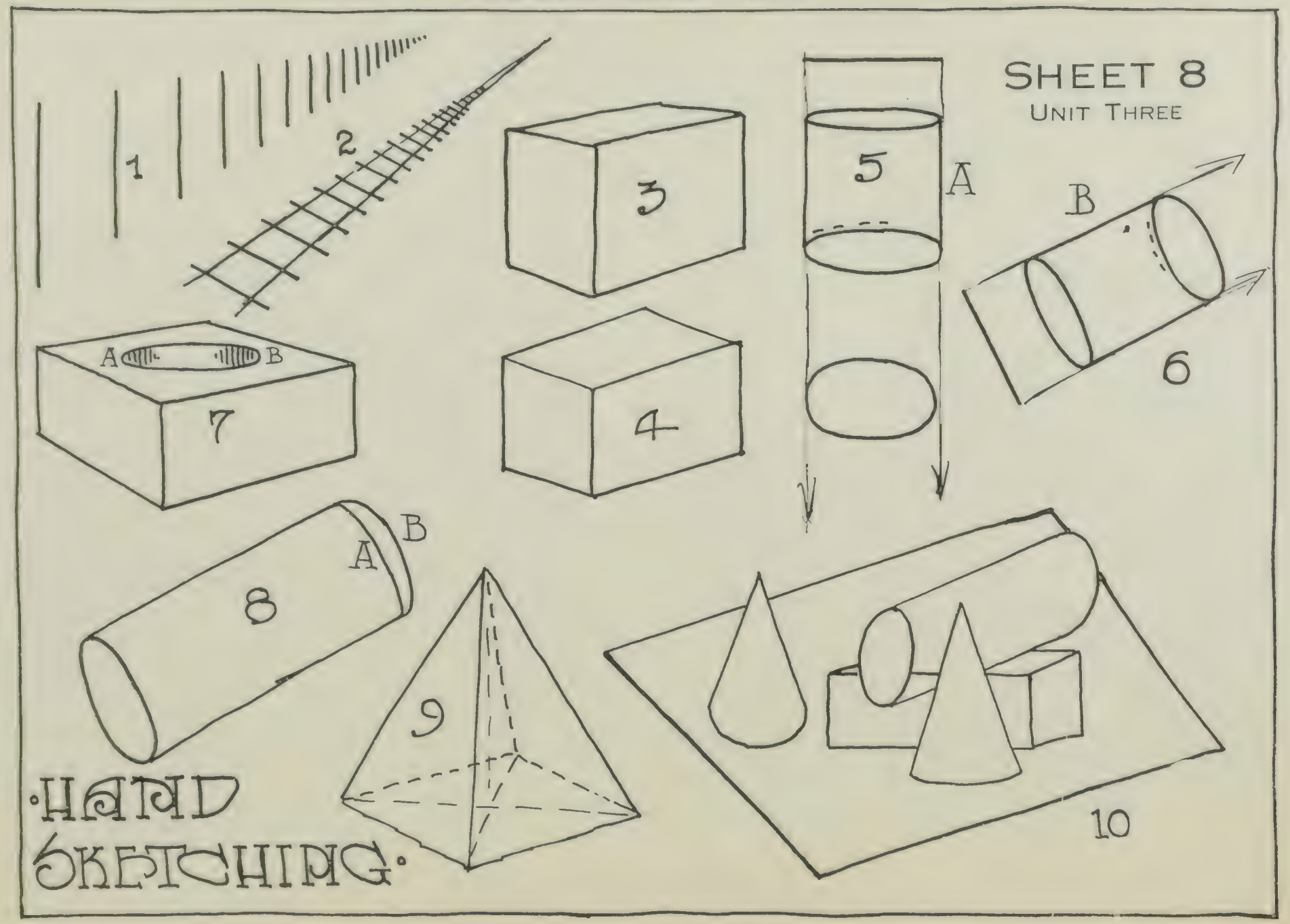
To get the location of the points: Take your transverse length FX in your compasses. Chase down the line from F and measure FX on both sides of CD. FX is also the length of KR and RH.

Find the other points in the same way, and then sketch in the whole ellipse.

In Fig. 3 you draw the elevation of a cylinder, 2½"x2", which lies at an angle of 30° to the ground, or H.P. Here you can see one complete end, and only half of the other. Put half a full view on the upper end. Get the 30° points, project them on to the end line and down across the cylinder to the other end line. Then project down to find your two ellipses in the plan.

Fig. 4 shows the plan of the same cylinder lying on its side, and its side making an angle of 60° with XY. Proceed as in the last case.

This is a very important lesson.


SHEET 8
UNIT THREE
1
2
3
4
5
A
B
6
A
B
7
8
A
B
9
10
HAND
SKETCHING

HAND SKETCHING

In previous sheets you have done a certain amount of Hand Sketching.

The workman on a job has often to make a readable sketch on a piece of building paper, a piece of board, or on a shingle. He has to convey a thought which must be accurately understood by some other person. Often these sketches are very crude, but so long as they are readable, they are useful.

Finished drawings are made in the Drafting Office.

Working sketches, done in a hurry, are made in the shops or on the job. A knowledge of Hand Sketching is just as important a subject as accurate Drafting.

It is assumed that the student has received the elements of Model Drawing in his elementary school, that he knows the first rules in Perspective, and that he knows how to use a pencil in Sketching. But for the benefit of those who know these things and of those who do not know, a brief recapitulation is now given.

In sketching use a soft pencil. Use the side instead of the point, and swing the whole hand from the wrist. Do not attempt to get a fine finished line, but try to get the general direction of the line. The rules of perspective may be neglected in making working sketches of small objects, though they look odd to a trained eye.

Fig. 1 illustrates fence posts. Fig. 2 illustrates ties on a railroad. These depend on the fact that things appear to get smaller as they recede.

Compounding Figs. 1 and 2 we get a prism as shown in Fig. 3, which looks better than the prism in Fig. 4.

From your knowledge of the circle you can read Figs. 5, 6.

A and B are cylinders in correct drawing.

In a sketch of a square nut, as in Fig. 7, AB is always horizontal, no matter what the position of the nut.

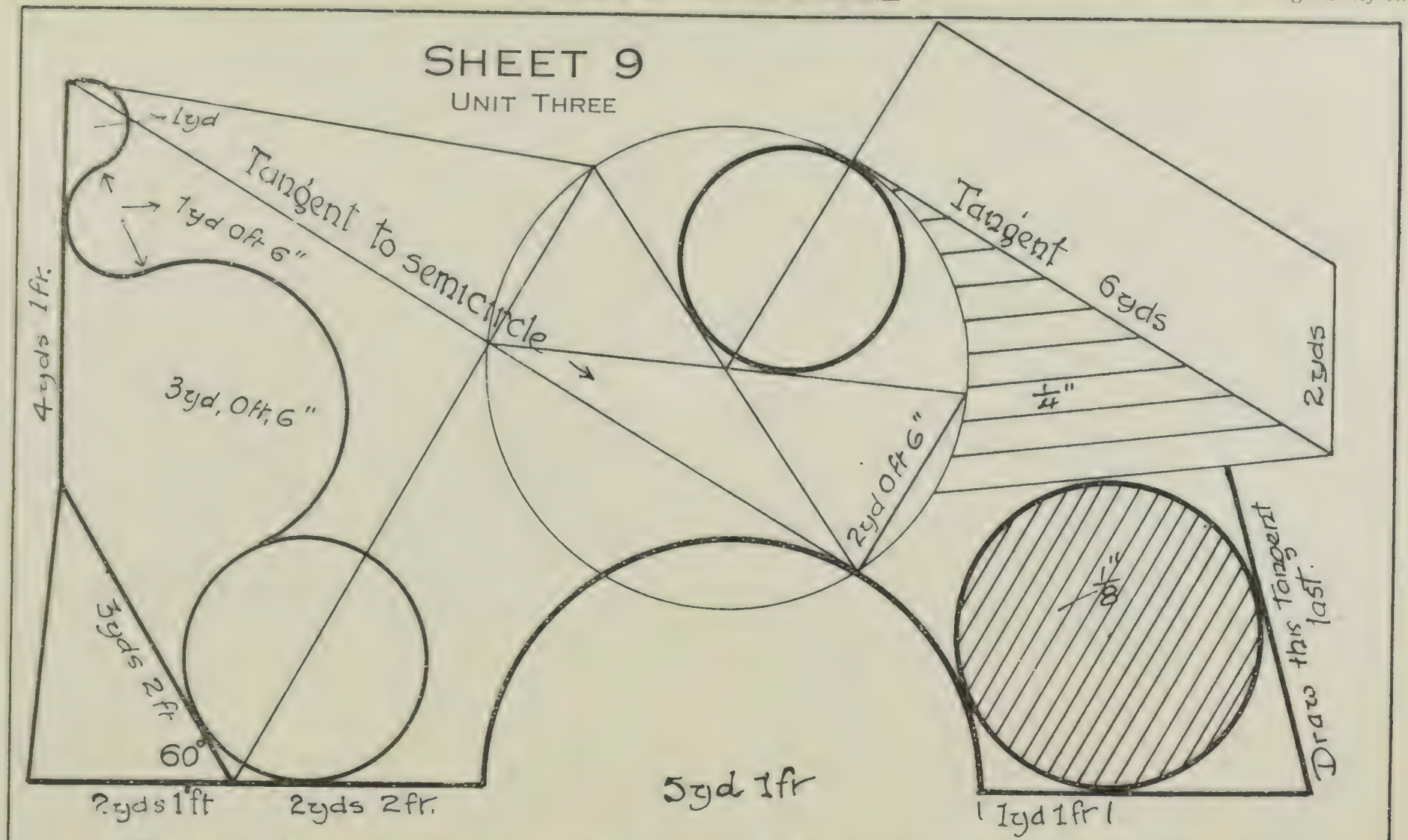
In the sketch of the piece of rod, Fig. 8, the major axes of the ellipses are always at right angles to the sides. Is A or B the correct ellipse, or are both wrong?

Fig. 9 illustrates the method of sketching a square pyramid. You first find the base. Then find the diagonals, and from their intersection raise a vertical line.

In a later sheet you will be shown certain types of conventional drawing. Meantime make a large drawing, as nearly correct as you can, of the sketch in Fig. 10.

This large sketch forms Sheet 8, Unit 3.

PROVINCIAL LIBRARY,
VICTORIA, B. C.



This sheet is a practice sheet partly on Scale and partly on circles and tangents Take all your lengths from a scale.

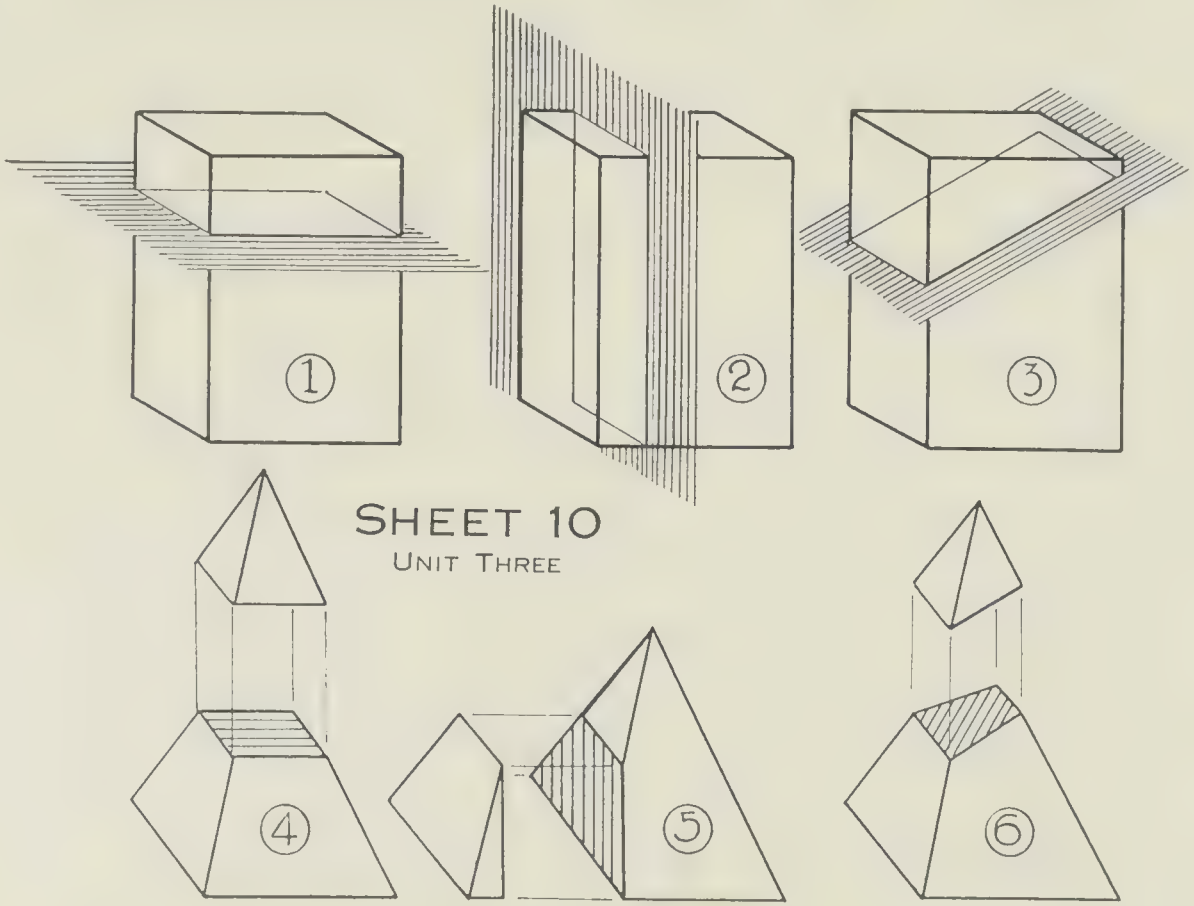
Make your scale where this lettering now is You take 3/4" to represent a yard. This sheet needs some thought.

SECTIONS. SHEET 10—UNIT THREE

A plane is a perfectly flat surface, and it may be horizontal, Fig. 1; vertical, Fig. 2, or oblique, Fig. 3.

You could take the prism in Figs. 1, 2, 3, and get it cut on a circular saw, and the section face left would be as in Figs. 1, 2, 3. The saw, in its motion, moves in a plane. The shaded portions are known as cutting planes. You can compare them to the plane of a circular saw. When such a plane cuts a solid you get a section of the solid, and the cut face exposed is called the section face. A section face is always shaded to show that it is a cut face.

In Figs. 4, 5, 6, you have the three types of planes cutting a pyramid. By removing one of the sections some distance, as shown in the diagrams, you can see clearly the section faces. Copy the sheet to a larger scale.



At this stage you are ready to attempt inking in and French Curve work.

There are no set rules to guide you in using the ruling pen. But take care that you do not put too much ink inside the nibs, as it will hold only so much, and if there is too much of a load it will relieve itself immediately you put it on paper. Use the rounder back of the pen against your straight-edge so that the inked line will not be in contact with the straight-edge. You will learn to ink in by making mistakes.

The French Curve is just a curved ruler to rule over curves that you have sketched in lightly. Experience and mistakes will teach you.

UNIT THREE EXERCISES

END ELEVATIONS. (See Sheet 2—Unit 3)

1. Draw both end elevations of Fig. 4.
2. Draw one end elevation of Fig. 11.
3. Draw both end elevations of Fig. 6, Sheet 10, Unit 2.
4. Draw the end elevation of the tenth figure in Sheet 1, Unit 3.
5. Draw end elevation of last figure in same sheet.
6. Sketch the plan, elevation, and side elevation of a man.

THE CYLINDER.

7. A cylinder, 3½″ long and 2½″ diameter, lies on the H.P., and the axis makes 75° with V.P. Show elevation.
8. The same cylinder is placed, balanced on the H.P., with its axis parallel to the V.P., and the axis also inclined at 75° to H.P. Show plan and elevation.
9. Develop a cylinder whose diameter is 3″ and length =1″ When a cylinder is cut off like this it is known as a cylindrical slab. A coin is such a slab.

DEVELOPMENT.

10. Take the parts of an ordinary match box, split them open and draw the stretch-out.
11. Take an envelope and draw its development.
12. Show the lay-out of a paper sack.
    Note: In the preceding three questions you have the terms "stretch-out," "development," "lay-out." They all mean the same thing.
13. Show the lay-out of a spice tin.
14. Show exactly how much paper would be required to cover a hexagonal prism.
15. Take a slab (see Question 9) off a triangular prism, and develop its lay-out.

HAND-SKETCHING.

16. Sketch a triangular prism in different positions.
17. Sketch a square pyramid and a cube together.
18. Sketch a cone and a sphere together.
19. Sketch any of the Tracery exercises you have done so far.
    Note: In sketching do not spend time on a fine finish. Get the general direction of your line. The aim in hand-sketching is to convey your thought as rapidly and as clearly as possible. Use an "H.B." pencil, or even a "B"

GENERAL.

20. From a point A, you go 2½ miles due north, then 4¼ miles due east, and then south 5 miles. Then you go northwest 3 miles. How far are you from your starting point?

21. You have a long room 20′x10′. 9′ up from the floor on one of the long sides is a spider which has to go to a point on the opposite wall 3′ down from the ceiling, this point not being directly opposite the other point. Find out the shortest path the spider can take. Think of your room as a prism and develop it.

22. The same spider is on the wall at the floor level, and is 3′ away from the corner. It has to cross the corner and reach a point on the other wall where the wall and ceiling meet, this point being 4′ away from the corner. Show by a diagram the shortest path.

23. The spider sits on the apex of a square pyramid. Show its shortest way to the base edge. What do you learn from this?

24. If you revolved a circle on its diameter, what solid would it track out?

25. Revolve your set square on the hypotenuse and describe the solid you so make in your revolution.

26. A carpenter asks you to lay off the plan of a basement 40′x60′ for him, and all you have is a piece of string. Could you do this? If so, show how.

27. A ship's compass is 15° wrong. The ship has to go 30 miles. When she has gone so far, how far distant is she from her destination?

28. A mouse, whose eye is 1″ above its feet level, sits on the top of a 6″ sphere. How far down can he see? Show by a diagram.

29. A 4″ sphere is placed in a corner. A wedge with a 30° slope is shoved under so that it touches. Keep shoving the wedge in until its point touches the wall. Show the different positions of the sphere as it rises. How far is your last centre from your first? Can you find in your diagram another similar length?

30. Take a point on the side of a pyramid. Travel round the pyramid the shortest way till you reach a point 2″, or any distance, immediately below the your starting point.

TRACERY.

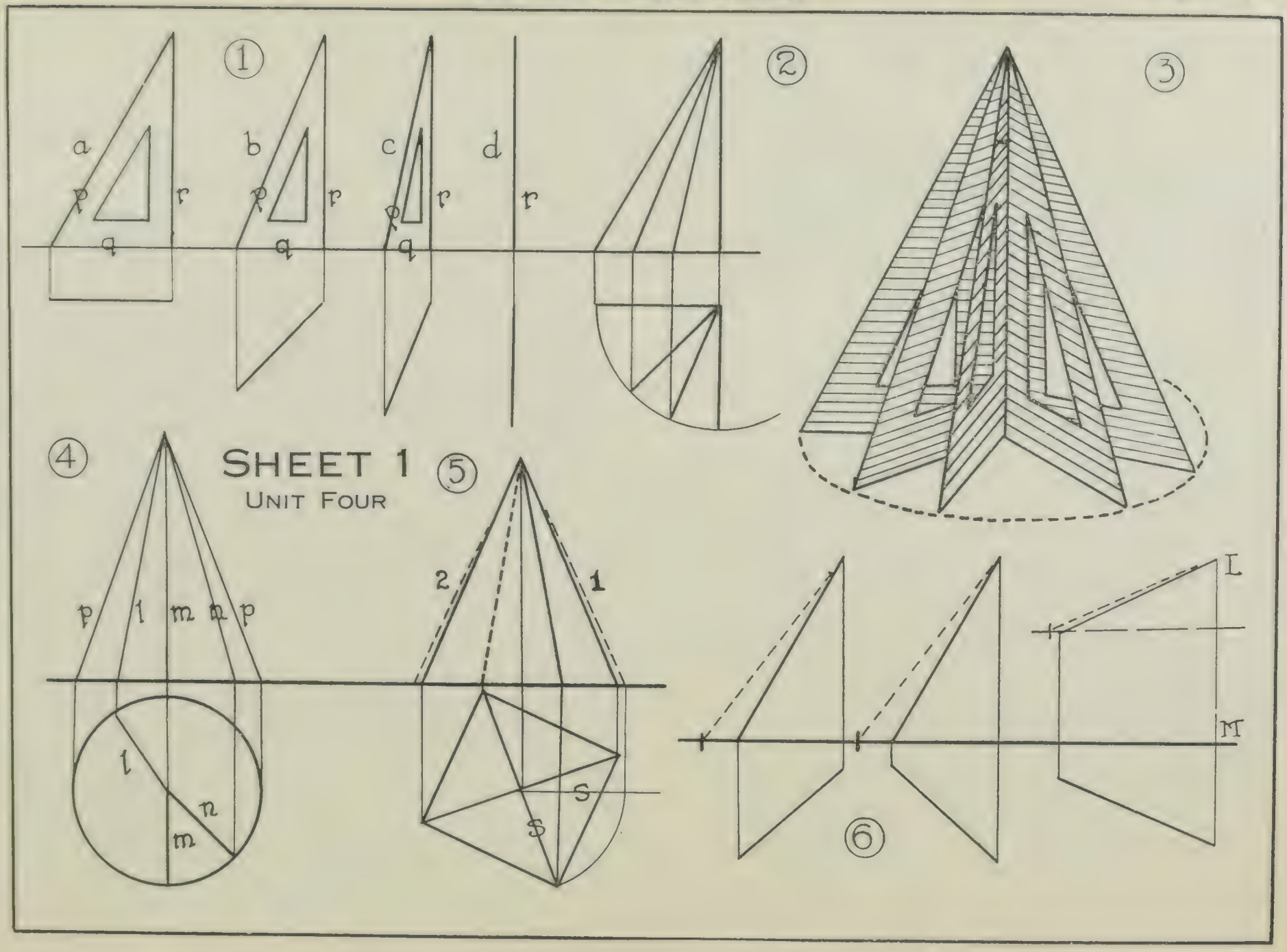
31. Following the weaving pattern in Sheet 5, Unit 2, take a 2″ side hexagon, and put a straight line design inside it.

32. Take a rectangle 2″x6″ and put a circular weaving design inside it, the design to touch the border lines.

33. Take a 6″ square and inside it put four circular bands, each band ⅜″ wide, and with the outside diameter of each circle equal to four inches.

34. Inside a 6″ equilateral triangle inscribe three circular bands to interweave.

NOTE: In Questions 33 and 34 there are two possible solutions to each. You may have (a) the circles touching two sides, and (b) the circles touching only one side. Did you ever ask yourself why you get so many Tracery exercises? There is a reason.


1
a
b
c
d
p
q
r
2
3
4
SHEET 1
UNIT FOUR
5
p
l
m
n
p
l
n
m
2
1
s
s
6
L
M

In drafting you have true lines and apparent lines. A true line is one which has its true length shown. An apparent line does not show its true length.

In Fig. 1 set up your set square as in *a*. This is a full front view of your square, and you know it is because your plan of it is parallel to the V.P. You could back up your square to lie right on the V.P. All lines are true that lie on the V.P., and also that lie flat on the H.P. Now swing your square round to the position in *b*. In this elevation you have shortened up *p* and *q*, which are now apparent lines, *but your height r is still the same.* Swing to position *c*. There is further shortening of *p* and *q*, but with the height *r* constant. Swing now to *d*. Here *p* has disappeared into the height *r* and the other disappeared entirely, but the height *r* remains the same.

In looking at the plans in these three positions you will observe that the length is constant.

In Fig. 2 the three lines, *p*, are shown in one diagram. Their plans are the same as in Fig. 1. You will notice that they are radii of a circle, and are equal. This figure represents one quarter of a right cone.

In Fig. 3 you can demonstrate this yourself by swinging your set square on its height as shown. The front view will give your varying apparent sizes of the true side *p*, but when you look down on it you see that a circle has been described by the positions of *q*, and that all the plans of your apparent lines in the elevation are the same.

Fig. 4 shows the plan of a right cone. Draw any plan lines *l, m, n,* and throw them up into the elevation, as *l, m, n,* which are all apparent. The true length is *p*.

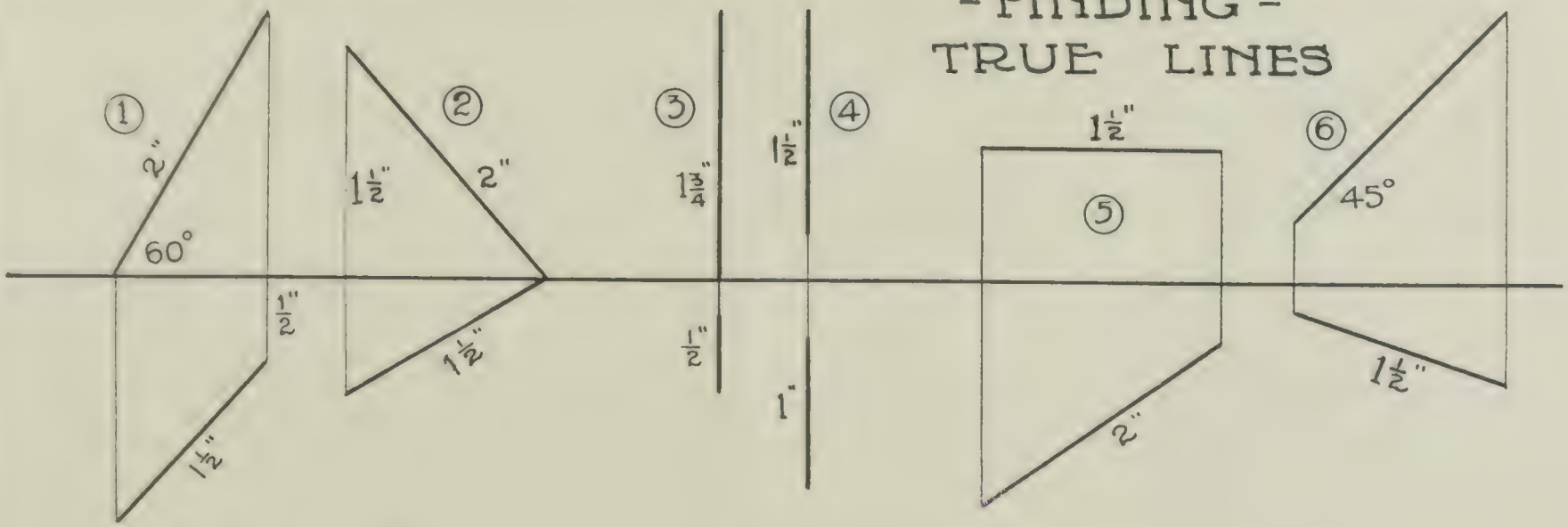
Fig. 5 shows the plan and elevation of a square pyramid. All the side edges in elevation are apparent. To get the true edge you have to take a plan line *s*, swing it so that it is parallel to the V.P., and then project up to the XY. The dotted line *1* is the true length of the side edge. This is the common way of finding a true line. But you will find it handier in drafting just to simply lift your plan line *s*, and set it against your height. You then get your true line, 2.

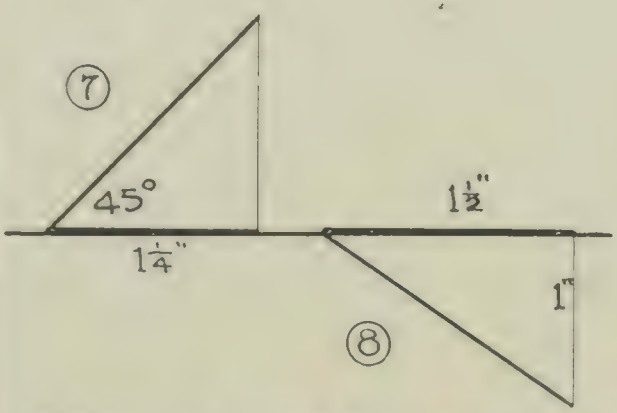
To find a true line: Place your plan, which is constant, against your height, which is constant, and complete your triangle. Learn this rule by heart.

Fig. 6 illustrates this method.

A cone is the revolution of a right angle on a side, Fig. 3.

- FINDING - TRUE LINES





9

A line of apparent length, $1\frac{3}{4}$", in elevation is at 60° to XY. Its plan shows as a line of 1". Show true line, using both methods.

10

A line of apparent length, 2", shows in elevation with one end on XY, and its height is $1\frac{1}{4}$". Its plan is $1\frac{3}{4}$". Show true length

11

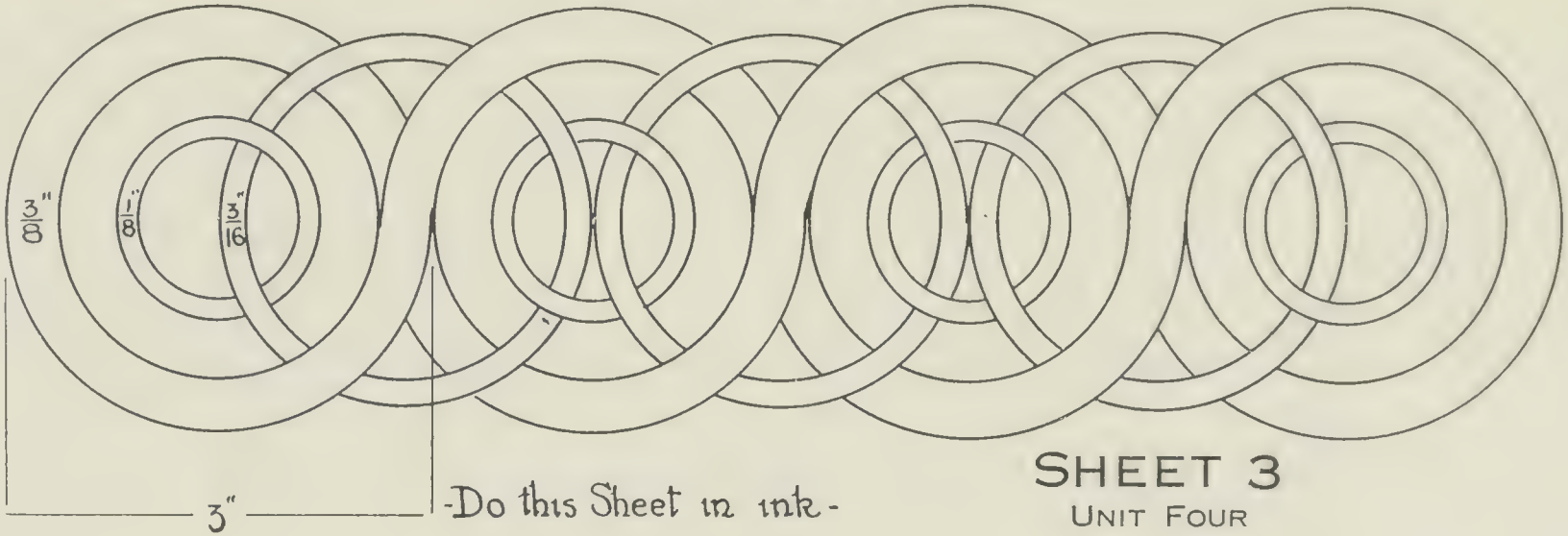
A line of apparent length of 2" stands vertically on XY. Its plan lies at right angles to XY and $\frac{1}{2}$" away from it. Find true line.

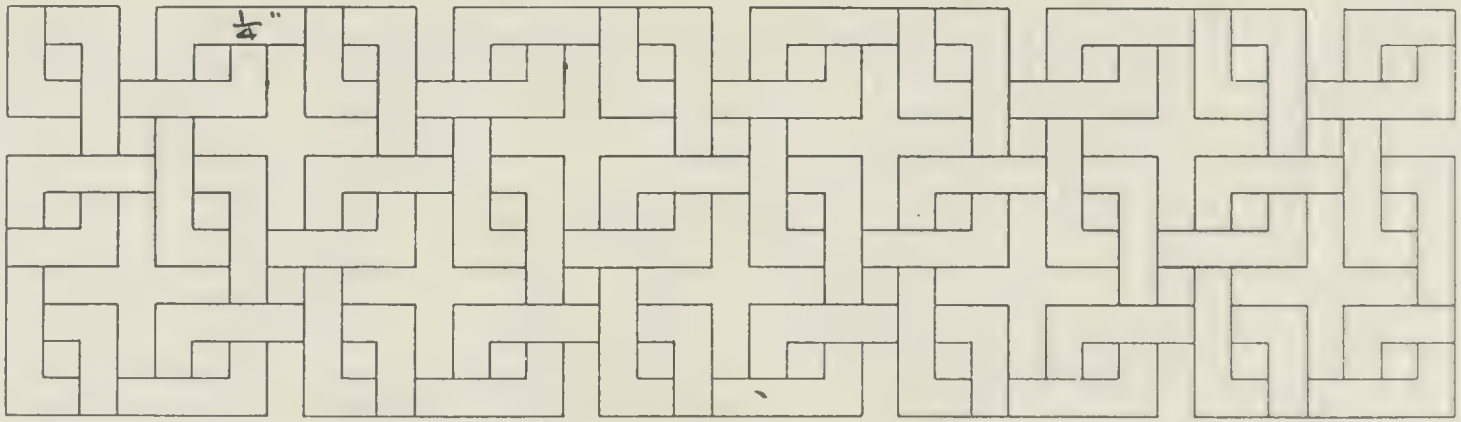
USE A MATCH FIRST TO LOCATE POSITIONS. REFER TO LAST SHEET.

SHEET 2

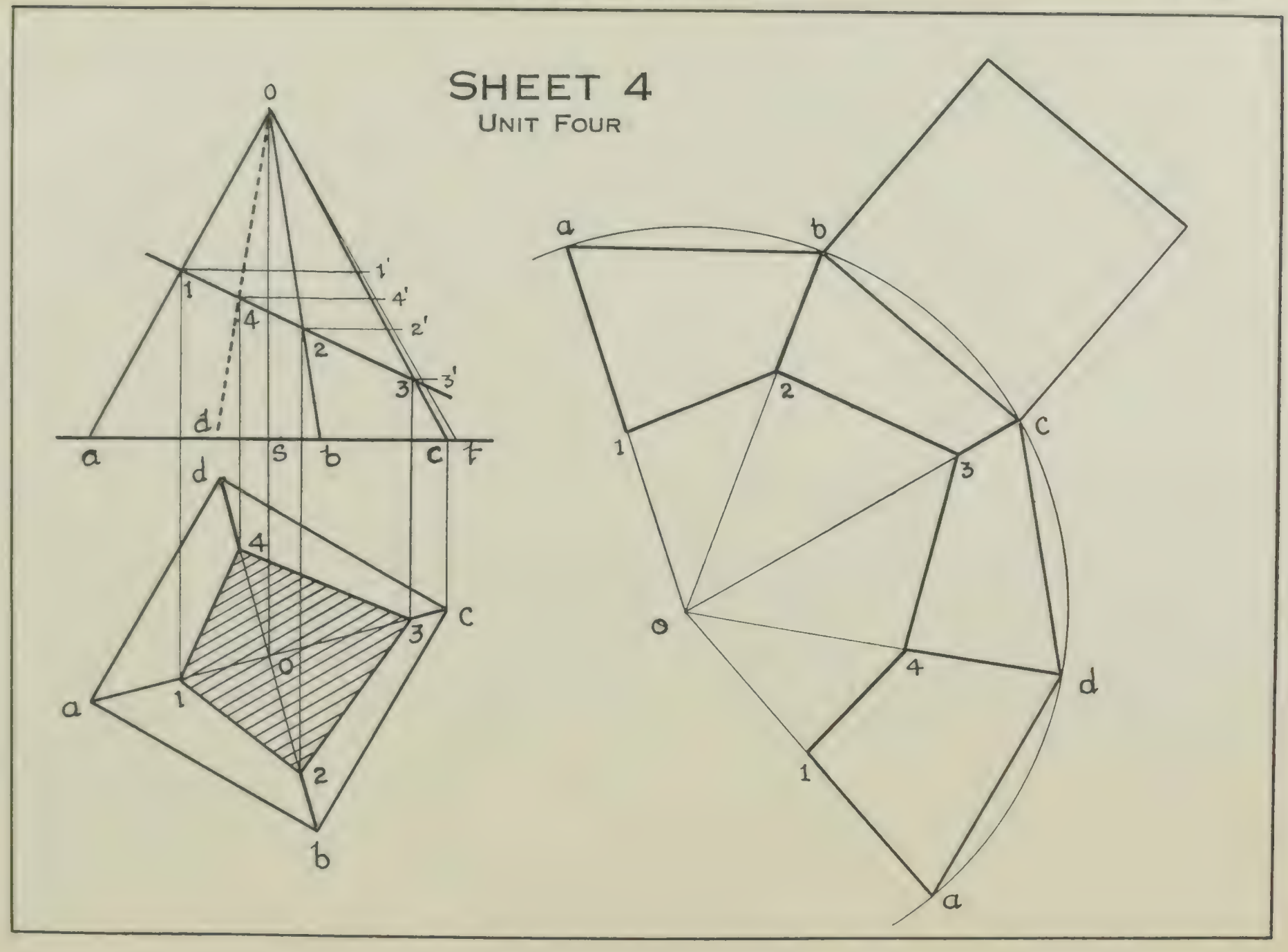
UNIT FOUR

-TRACERY-





PROVINCIAL LIBRARY
VICTORIA, B.C.


SHEET 4
UNIT FOUR
o
1
1'
4'
4
2'
2
3
3'
d
a
s
b
c
f
d
4
c
3
o
a
1
2
b
a
b
2
c
1
3
o
4
d
1
a

SECTION OF PYRAMID

A square pyramid, 2¼″ on base and 3″ high, stands on the H.P., and a base edge is at 30° to the XY. Its nearest point is ½″ from the V.P.

A cutting plane, which is perpendicular to the V.P., passes through a point 1½″ down from apex on one edge, and passes out at a point ⅝″ from the ground on the opposite edge. Show the section face in plan and develop the larger section.

Draw the plan and elevation as shown, and put in the trace or section line of your cutting plane.

Now the cutting plane must, in its path, cut your four edge lines in the elevation. Where a plane cuts a line you find a point. Find this out for yourself.

Indicate the section points as *1, 4, 2, 3*. Why not *1, 2, 3, 4?* You find that out now.

Point *1* in elevation lies on *oa*. It must therefore lie on *oa* in plan. Project it down. *2*, on the elevation line *ob*, must also be projected down to *ob* in plan. Similarly project down the points *3* and *4*. You will see that the section face is now numbered *1, 2, 3, 4*, and this order you will find useful in your stretch-out. A section face is always shaded, and should never have any lines but the shade lines, but, for instruction, lines are left in this case.

None of the edge lines are true lines in the elevation, and before you can develop you must have a true edge. From what you have learned about true lines in this unit, you lift your plan line *oc* and place it against the point *s* in the elevation, whence it extends to *t*. *ot* is the true length of all your edges, as they are all equal. Take *ot* in your compasses and swing an arc as *abcda*.

The problem is to lay off four triangles like *oab*, all joined together. You have already the true sides *oa* and *ob*, and the third side *ab* lies on the H.P., so it too must be true. Take *ab* in your compasses and step it off on your arc as *ab, bc, cd, da*. Connect these points on your arc to each other and also to *o*, and the resulting figure is the envelope of your four sides. Place a square on *bc*. Then if you care to make this in cardboard and set it up, you have your complete pyramid.

If you turn your pyramid around on its base the points *1, 4, 2, 3*, may have an infinite number of positions, *but their actual heights* never alter. Try it out on your model.

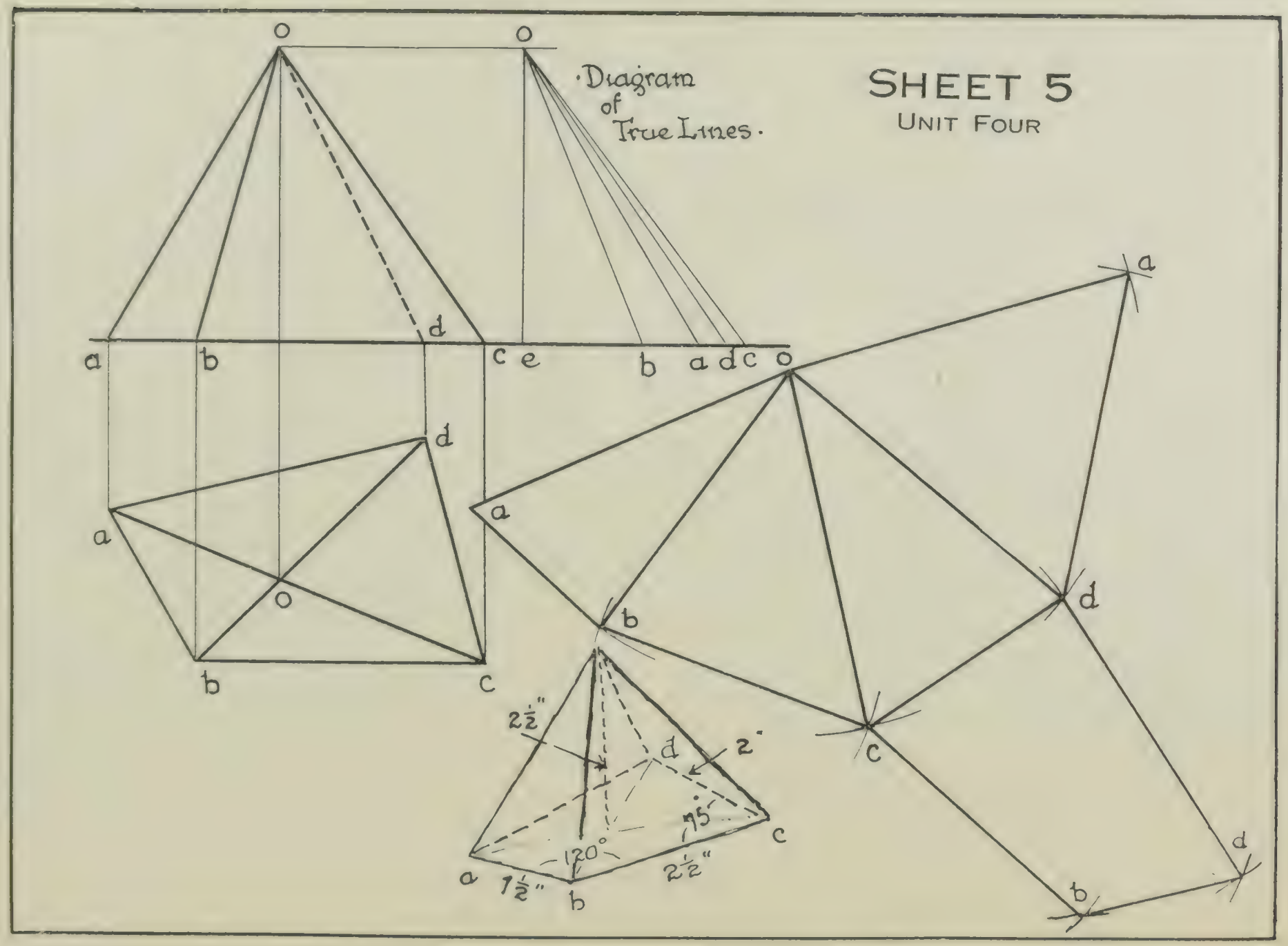
In swinging around, each point sometime or other, will fall on your true line *ot*, and when in that position will give you a true length of the section of your line. In practice you swing your points over on to your true line, as *1', 4', 2', 3'*. Lift *1't* from this true line and lay it on *oa* in your lay-out. Similarly lift *2't* and lay it on *ob*. Similarly *3't* on *oc*, and *4't* on *od*.

When you have done this you will find that you apparently have a line too many in your lay-out. Reason it out. Connect your points, and you have the lay-out of your sectioned sides.

Set it up in cardboard.

PROVINCIAL LIBRARY,
VICTORIA, B.C.

SHEET 5—UNIT FOUR



IRREGULAR PYRAMID

In this sheet you have another pyramid, but which is different from the regular square pyramid in your last sheet. All the triangular faces are different; the edge lines are different, and the base edges are unequal.

From the details on the rough sketch make your plan, with *bc* parallel to the XY. Join *ac* and *bd* intersecting at *o*. Throw up your points *a, b, c, d,* and *o; o* is 2½″ above XY. Complete your elevation.

All the elevation lines *oa, ob, oc, od* are not true. To get these true you make a diagram of true lines. Project *o* across. Now you have the height *oe* of all your apparent lines. To get a true line, you have learned that all you have to do is to place the plan of your line against its height. Lift the plan lines *oa, ob, oc* and *od,* and place them against the height *oe,* as *b, a, d, c.* Join these points to *o,* and you have your true lines. To develop, take the triangle *aob. ab* is a true line. Place it as shown and take the true line *oa* in your compasses and swing an arc from *a.* Take true *ob* in your compasses and swing from *b* to cut the first arc. You have now the true triangle *oab.*

Lift *bc* and swing it from *b.* Lift the true line *oc* and swing it from *o* to cut the former arc in *c.* This gives you the true triangle *obc.*

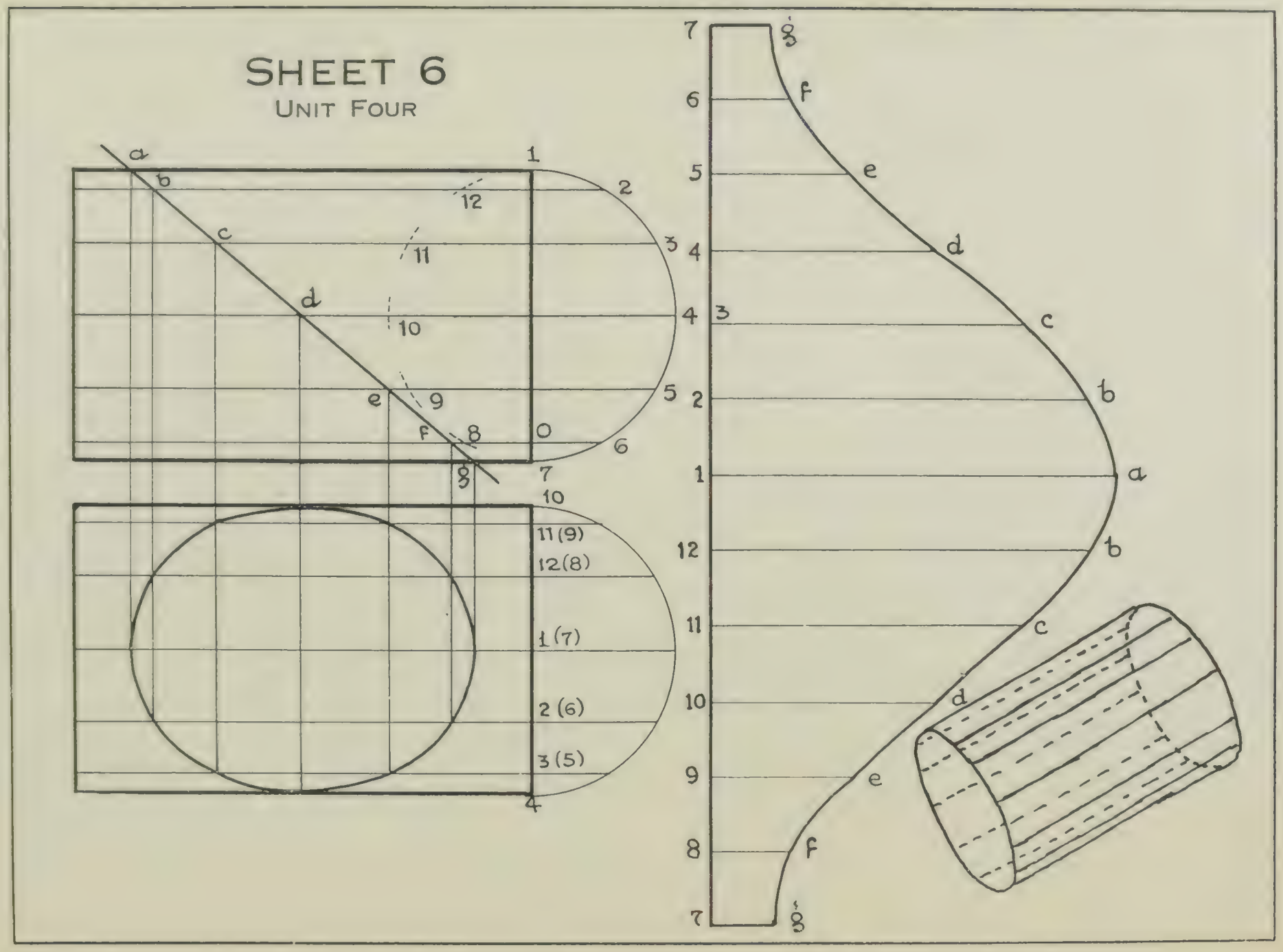
Lift *cd* from your plan and swing it from *c.* Take *od* from your diagram of true lines and swing it from *o* to cut the last arc. This gives you the triangle *ocd.*

To get the triangle *oda,* do as in the other triangles. You have now completed the envelope of the sides.

To get the base, swing *da* from *d,* and with *ac* lifted from your plan swing it from *c* to cut the arc in *a.* Lift *ab* from your plan and swing it from *a.* From *c* swing *cb* around to cut this arc in *b*—*abcd* is your true base.

If you cut this out in cardboard and set it up you will find that the base line *ad* of the triangle *oad* will fit *da* of the bottom. Similarly *bc* will fit *bc* and *ab ba.*

In this sheet you have learned to make a diagram of true lines, and how to make a quadrilateral, given the details. You will meet the diagram many times after this, so take care that you know this lesson thoroughly.


SHEET 6
UNIT FOUR
a
b
c
d
e
f
g
1
2
3
4
5
6
7
8
9
10
11
12
0
11 (9)
12 (8)
1 (7)
2 (6)
3 (5)
4

THE CYLINDER

Draw the plan and elevation of the cylinder as shown, 2½″ diameter and 4″ long.

A section cut is made to enter at *a*, ½″ from the end, and to emerge at *g*, ½″ from the other end.

In this sheet, as in Sheet 7, Unit 3, you need location lines. These lines are indicated on the rough sketch. Looking at this sketch you can imagine it a skeleton framework, and this thought will help you in your problem.

On the elevation end put a full half view of your end. A suggestion of a full view is also given.

Get your 30° points and do the same on your plan. Notate your points in pencil.

Draw your projectors in plan and elevation from these points on to your end lines, and then through the cylinder. You have now your skeleton.

Where the section line cuts these location lines in the elevation, notate the points as shown.

Before going any further, it would be advisable to take your old cylinder model and study it in connection with all these lines and points.

When you have thoroughly understood the positions of all the lines in both plan and elevation, drop the section points *a, b, c, d, e, f, g* down to the plan to meet their own lines. The points so found are points on an ellipse. Sketch in this ellipse, and if you have a French Curve finish the curve up properly. As a section face, the ellipse should be shaded, and the less section removed entirely, but it is left as it is in this exercise.

To develope the envelope of the side, lay out a line 7 7, and on it step off 12 units, each equal to 30° of your end circumference. The complete line 7 7 is approximately the same size as your end circumference.

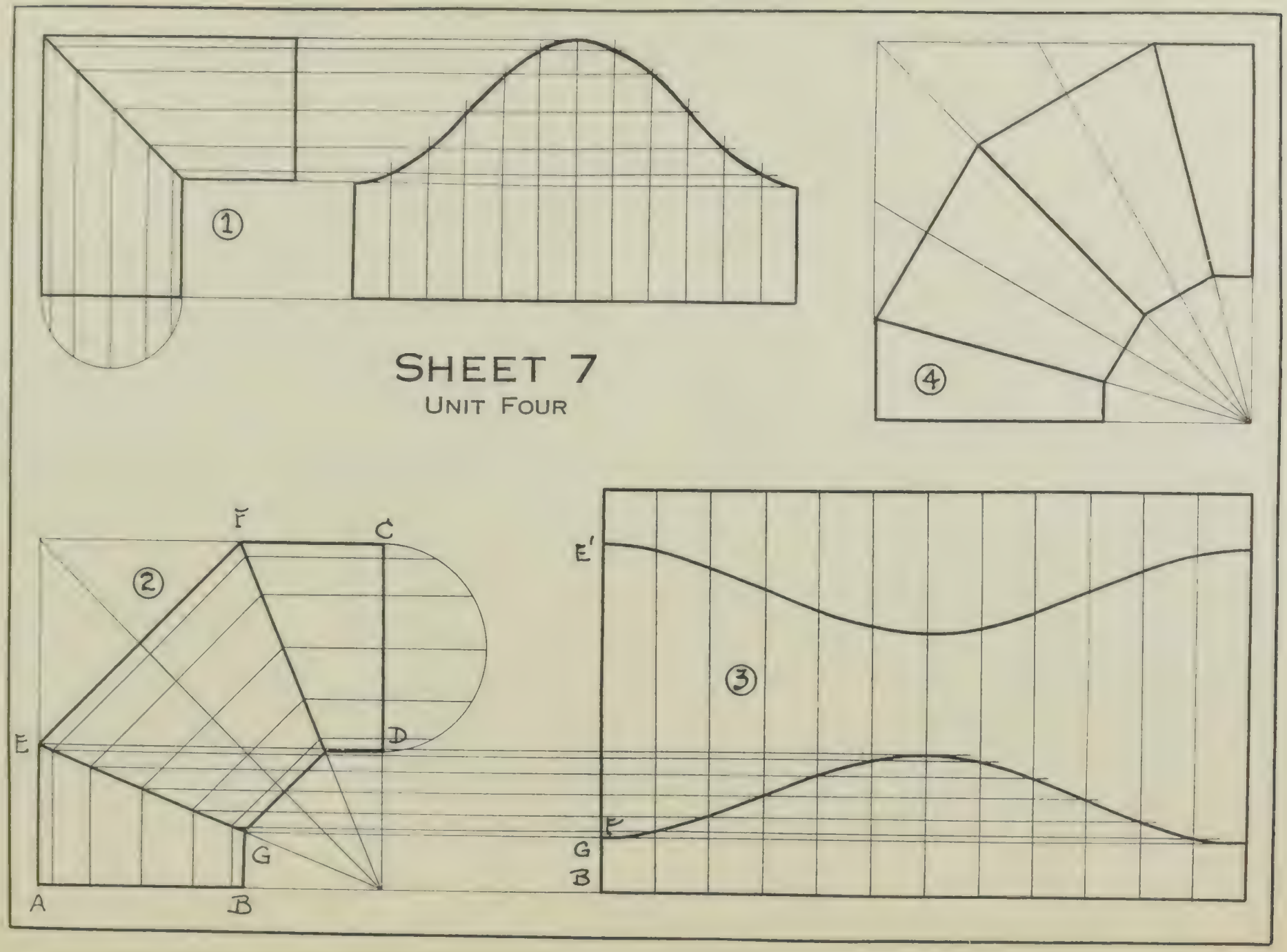
At each of the 30° points raise perpendiculars, which are naturally the frames in your skeleton drawing.

Lift *7g* in the elevation and lay it down as *7g, 7g*. Similarly lift *0f* and place as *6f, 8f*. Continue the process until all your lines are set off. You will have now a series of points, through which sketch the necessary curve.

In this drawing the right hand section of the cylinder is laid out, as it is more convenient to do so, and as it is exactly the same size as the other section. Generally, it is always the larger section that is developed.

This is an easy but important sheet. You will apply the principles in the next sheet.

SHEET 7—UNIT FOUR



ELBOWS

All cylindrical pipes follow the rules laid down in the last sheet.

Fig. 1 shows a two piece elbow. You will readily see that it is composed of two cylinders exactly the same in cross section. The length of pipe does not matter. The section line is called in this type of work the mitre line.

The pipe is 1¼″ in diameter. No plan is necessary. Put on your location lines as indicated. Produce your bottom line, and on this line produced lay off 12 units, which you take as before from your circular end. Raise your perpendiculars.

From your section points on your mitre lines draw transverse lines to cut the proper perpendiculars of your lay-out. If you have any difficulties consult your model, and use figures.

The points found are the points you want for your curve.

Fig. 2 shows the common three piece elbow.

Make a 3″ square and join the diagonal. Bisect the angles of 45° to get your mitre lines. Make AB and CD 1¾″ long, and raise perpendiculars to meet the mitre lines. Join the points on the mitre lines to get the middle section. You can see that you have the two end pieces the same, and you can prove that the middle piece is made up of two such end pieces.

On CD draw a half end view, dividing the semi-circumference into 30° arcs. Project your 30° points down onto CD, and produce them to meet the mitre line. From the points on the mitre line draw parallels to the side. From the points on the second mitre line drop perpendiculars on AB. You have now all your location lines. To develop the envelope produce AB, and on the line produced lay off 12 equal units of 30° of arc which you lift from your end semicircle.

Erect your perpendiculars.

The lowest section is developed as in Fig. 1.

To get the middle section lift EF and place it on top of GB at both ends of your lay-out.

Lift GB and place it on top of E.

Complete the rectangle. Make the top section the same as your bottom section. You do not need to worry about the middle section as it finds itself. This is known among boys as the Scotch method of cutting an elbow out of material.

A sheet metal worker makes this elbow so that the three sections can turn round on themselves. You can turn them so that all make only one complete cylinder.

Fig. 4 shows a four-piece elbow. Here you have two double units in the centre, and two single units outside. Altogether you have your right angle divided into 6, and each angle is 15°.

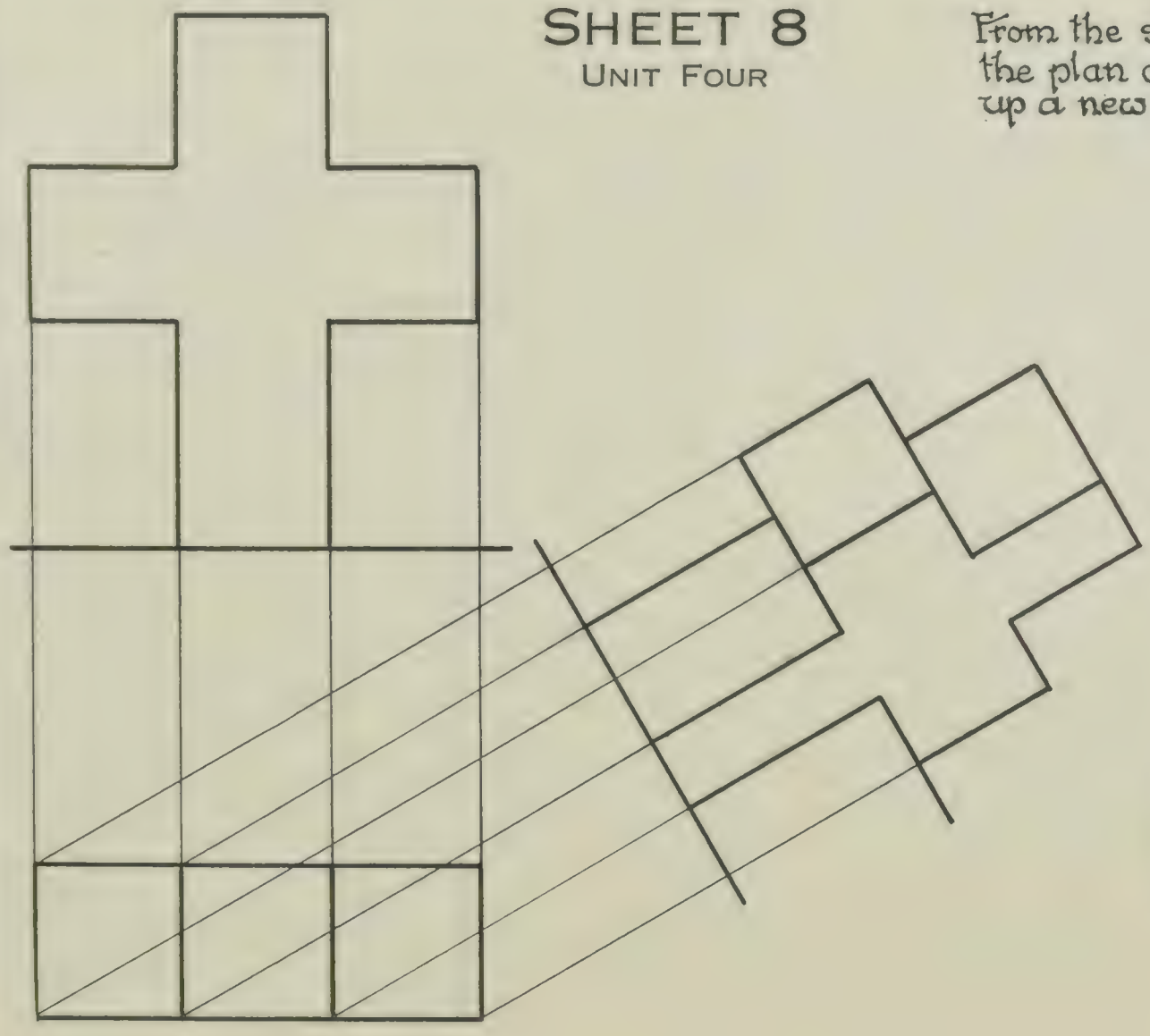
If you had a six-piece elbow, what would be the size of your angle? Figure it out.

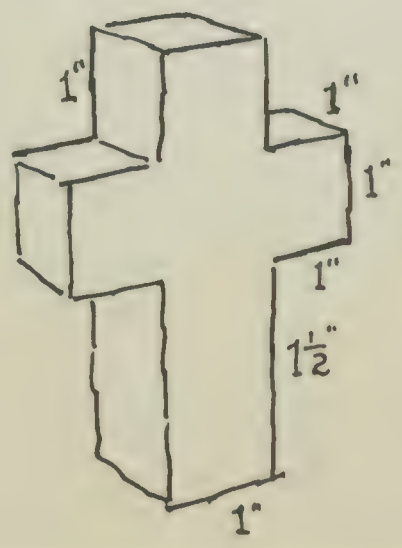
For all heating purposes the three piece elbow is in common use. Why not use the more easily made and cheaper two-piece elbow?

SHEET 8

UNIT FOUR

From the sketch below, construct the plan and elevation and throw up a new elevation on the 60° XY

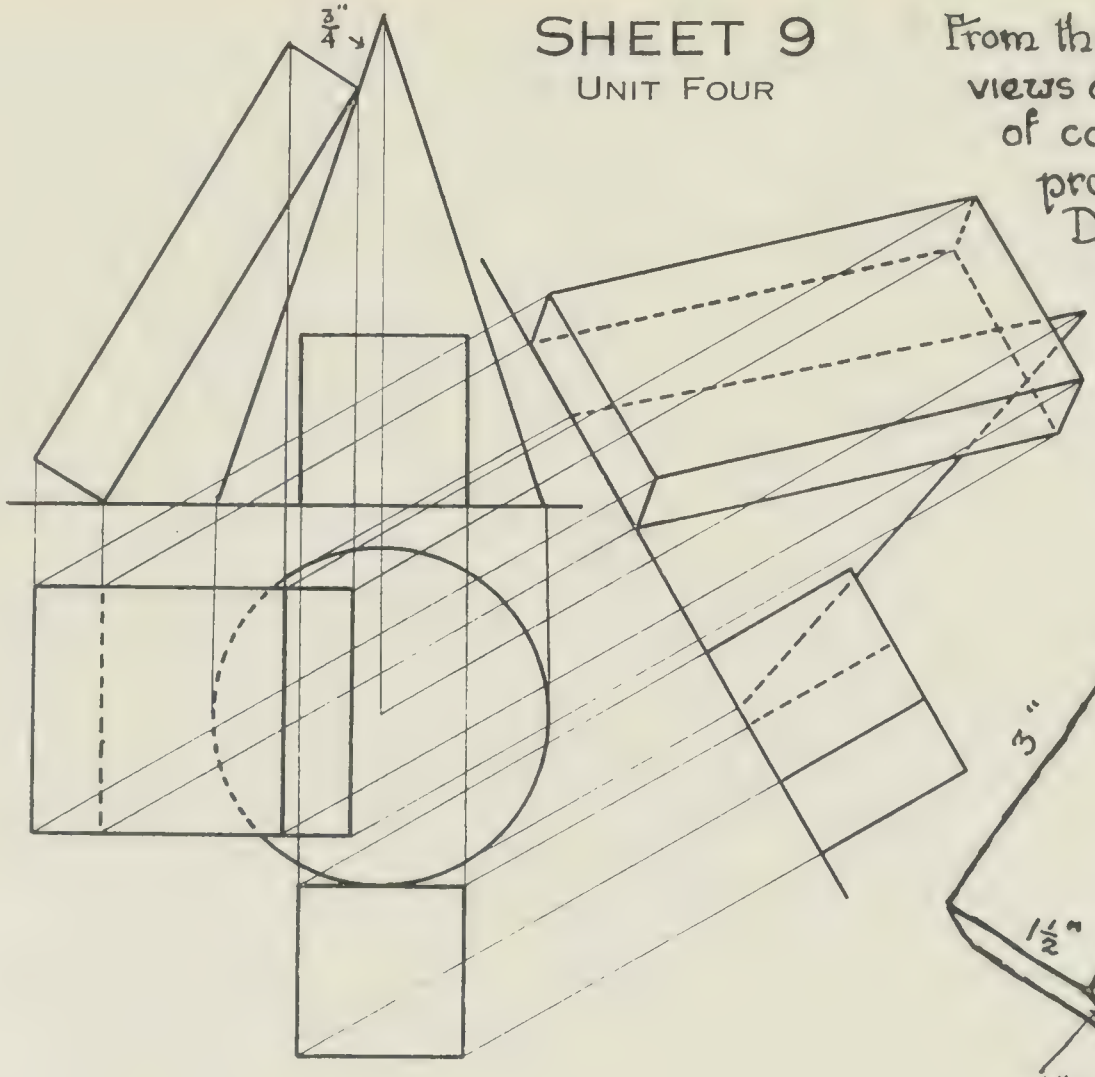


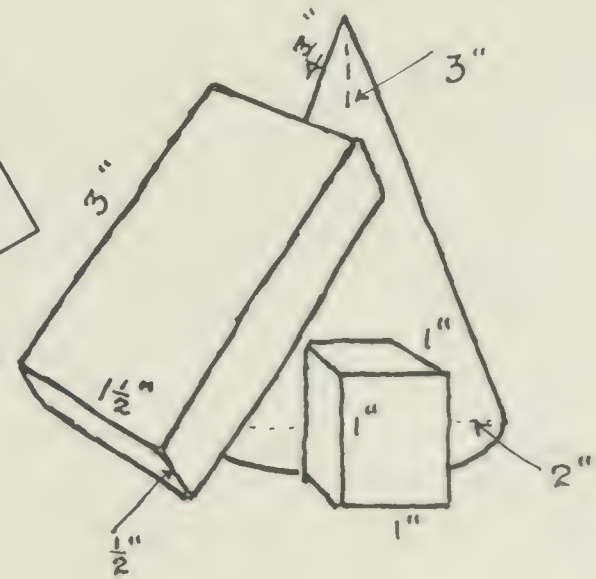


SHEET 9

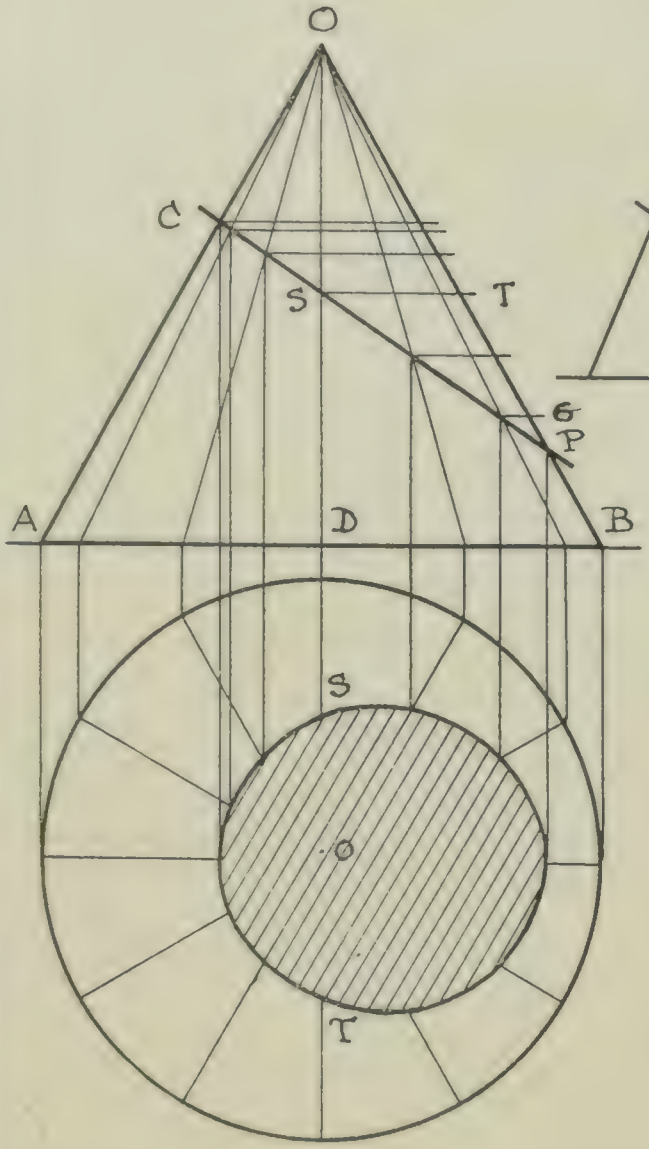
UNIT FOUR

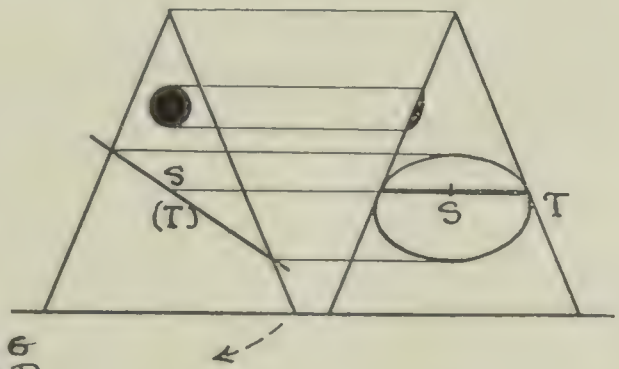
From the sketch below make the views as shown. Draw plans of cone and cube first; then project them into elevation. Draw elevation of slab and then project down into the plan. On a new XY show a new elevation the new XY being at 60° to old XY. Transfer all heights from the first elevation.



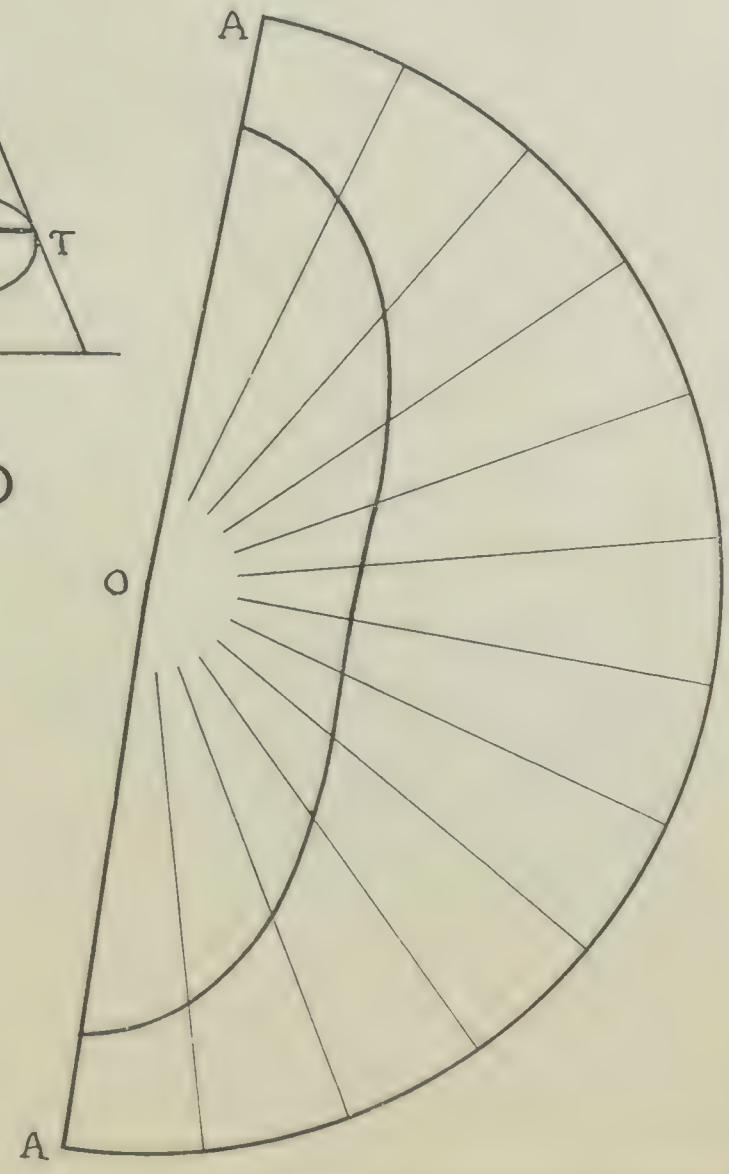


SHEET 10—UNIT FOUR





SHEET 10
UNIT FOUR



THE CONE

A cone is the revolution of a right-angled triangle on one of its shorter sides. You saw this in Sheet 1, Unit 4. What would you get if you revolved the triangle on the longest side?

Draw a circle of 3″ diameter which is the plan of the cone. Project to get the triangle OAB.

On the plan find your 30° points, and join them all to the centre to get your location lines. You have now the plans of the hypotenuses of twelve right-angled triangles. See Fig. 2, Sheet 1, Unit 4.

Throw these plan lines up into elevation.

Now take a cutting plane, CP, to enter 1¼″ down from O and to come out ¾″ up from B.

Notice Carefully. This plane cuts all your elevation lines in certain points. Project these points down to fall on the corresponding plan lines. Figures are not shown in this diagram.

When you come to the section point on the elevation OD you find it will not cut its own line in plan.

Project the point S out to meet the edge line at T. Lift ST and mark it off on the plan line, as OS and OT. If you look at Fig. 2 you have the first cone in the same position as your large cone. Looking at it you get an end view of your line ST, the line you are trying to find. Pull your cone around clockwise through 90°, and you get a front view of your cut face, revealing the line ST in its true length. This is what you did actually on your elevation when you drew ST, which is half of the line you want.

It is rather curious that the section of a cylinder is an ellipse, and that a cone has the same section. There is a common idea that the section of a cone is egg-shaped.

To develop the envelope of the cone, take your true edge OA and swing an arc. Along this arc mark off 12 units of the same size as the 30° arc on your plan. This will give approximately the circumference of your circle. If you join OA, OA, you get the complete envelope.

To get the lay-out of the section, you connect your points on the arc to your centre, thus getting your location lines. In your elevation, two lines only are true, OA and OB. The others are apparent, but their true length is OA or OB. As you turn the cone around on its base, all your section points alter position, *but their height does not change.*

Project them all across on to OB, and you have the true lengths of our sections of lines.

Starting off on OA, OA, mark off BP. On the next equal pair mark off B6, and so on. Then finish with French Curve. You may use pencil letters and figures, but these must be rubbed out on the finished drawing.

From your knowledge of location lines this sheet should not be difficult.

PROVINCIAL LIBRARY,

UNIT FOUR EXERCISES

SECTIONS.

1. Make a regular pentagon of a 1½″ side. Join the diagonals. This is the plan of a pentagonal pyramid. Project for the elevation, making the height 2″. Take any section cut in the elevation and show the cut-face in plan. Then develop the bottom section of the pyramid.
2. Lay a square pyramid on its face (Fig. 4, Sheet 2, Unit 3). Take a section cut to go through top side and end. Show section in plan.
3. Place a square pyramid on its edge as in Fig. 8, Sheet 2, Unit 3. Take a section cut to go through top edge, both side edges, and out through the bottom. Show plan and section.
4. Do the same with the pyramid in Fig. 11, same sheet.
5. In the plan of Fig. 10, same sheet, draw a vertical section plan parallel to V.P. Show section in elevation.
6. In the plan of Fig. 9, same sheet, draw a vertical section plane through the plan, but not parallel to the V.P. Show elevation.
7. In the elevation of Fig. 6, same sheet, draw a section plane to cut through the base and three side edges. N. B.—There is an error in this elevation, as you should have found when doing it.

DEVELOPMENTS.

8. Make an irregular pentagon. Join the diagonals. This is plan of an irregular pentagonal pyramid. Throw up the point to your XY. At the projection point of your intersecting diagonals, raise a 2½″ line at an angle of 75°. This is the apex of your pyramid. Complete your elevation, and then complete your plan by projecting your apex so that it hits any of your diagonals in the plan. Make a diagram of true lines, and develop.
9. Two pipes, instead of meeting at 90°, meet at 120°. Develop one piece.
10. Similarly, make a three piece elbow to include an angle of 120° instead of 90°. Develop one end piece.
11. Take the plan and elevation of a cylinder and cut the elevation with a plane to go in at the top edge and come out through the end.
12. Similarly, put a vertical section plane in the plan to cut the cylinder at an angle of 30° with V.P. Show the cut in elevation.
13. Draw a sketch of a five piece elbow.
14. Take any cone and (a) make any horizontal cut in the elevation; (b) a vertical cut at right angles to the V.P. What would you need further to show the section in (b)? You will meet this section later.

TRUE LINES.

15. Show true lines from following data:—
    a. The plan is 2″ long and lies at 30° to XY. Height is 1½″.
    b. The apparent length in elevation is 2½″ and and makes an apparent angle of 75°. Its plan is parallel to XY.

c. The elevation is parallel to H.P., and 1″ up, and appears as 2″. Its plan is 2½″.

d. The elevation is parallel to V.P., and is 3″ long. The plan is 2″.

e. Apparent elevation 1¾″, apparent plan 1¾″, and at an angle of 30° with XY.

f. A point in elevation; 2″ in plan.

g. 2″ in elevation; 2″ in plan. How many cases?

h. 2″ in elevation, apparent, and angle 60°. Apparent plan 2½″.

i. A point in plan; 3″ in elevation.

NEW ELEVATIONS.

16. a. Draw a letter H in plan and elevation, and show a new elevation on a new XY at 60° to old one.

b. Take your pyramid in Fig. 8, Sheet 3, Unit 3 and throw up a new elevation to the left, 60°.

c. Take your pyramid in Fig. 11, same sheet, and throw up a new elevator to the left, 60°.

d. Throw up plan of Sheet 5, Unit 3, to the right on a new XY at 60° to old XY. The end of your small cylinder is elliptical.

GENERAL.

17. a. With your own models set up a group, and make a working drawing.

b. Sketch your group above.

c. Sketch your Tracery in this Unit.

d. Make a sketch of a three piece elbow with a two piece lying in front.

18. Print with your ruler and square, following Fig. 6 in your first lesson in lettering, making the letters ½″ high:—

ANTITRANSUBSTANTIATIONALISTS.

19. In Sheet 5, Unit 4, take an oblique section plane in the elevation, show the section in plan, and develop the bottom part of your pyramid. (Follow Sheet 4, Unit 4).

20. In Sheet 8, Unit 4, take an oblique section plane to cut through the upright top member, and also the cross arm. Show the section in plan, and also the section on your new elevation.

21. In Sheet 9, Unit 4, take a horizontal cutting plane in the elevation, 1″ above the H.P. Show sectioned plan, and the sections in the new elevation.

TRACERY.

22. Take four units of the circular weaving design in Sheet 3, Unit 4, and place in a square of 4″ side.

23. Take three units of the same design and place in an equilateral triangle of 6″ side.

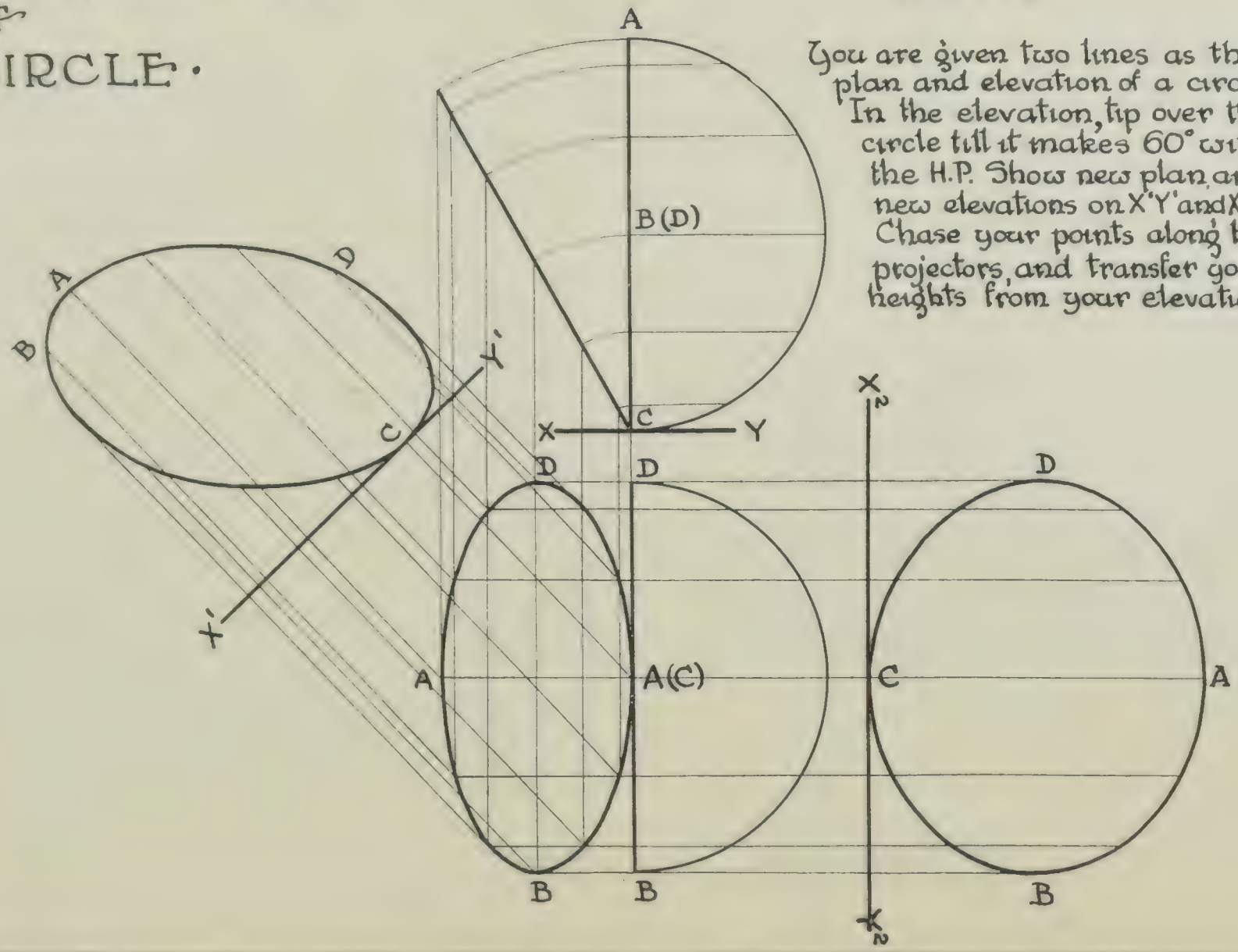
NOTE: There are two cases in each of the above questions. See Question 34, Unit Three Exercises.

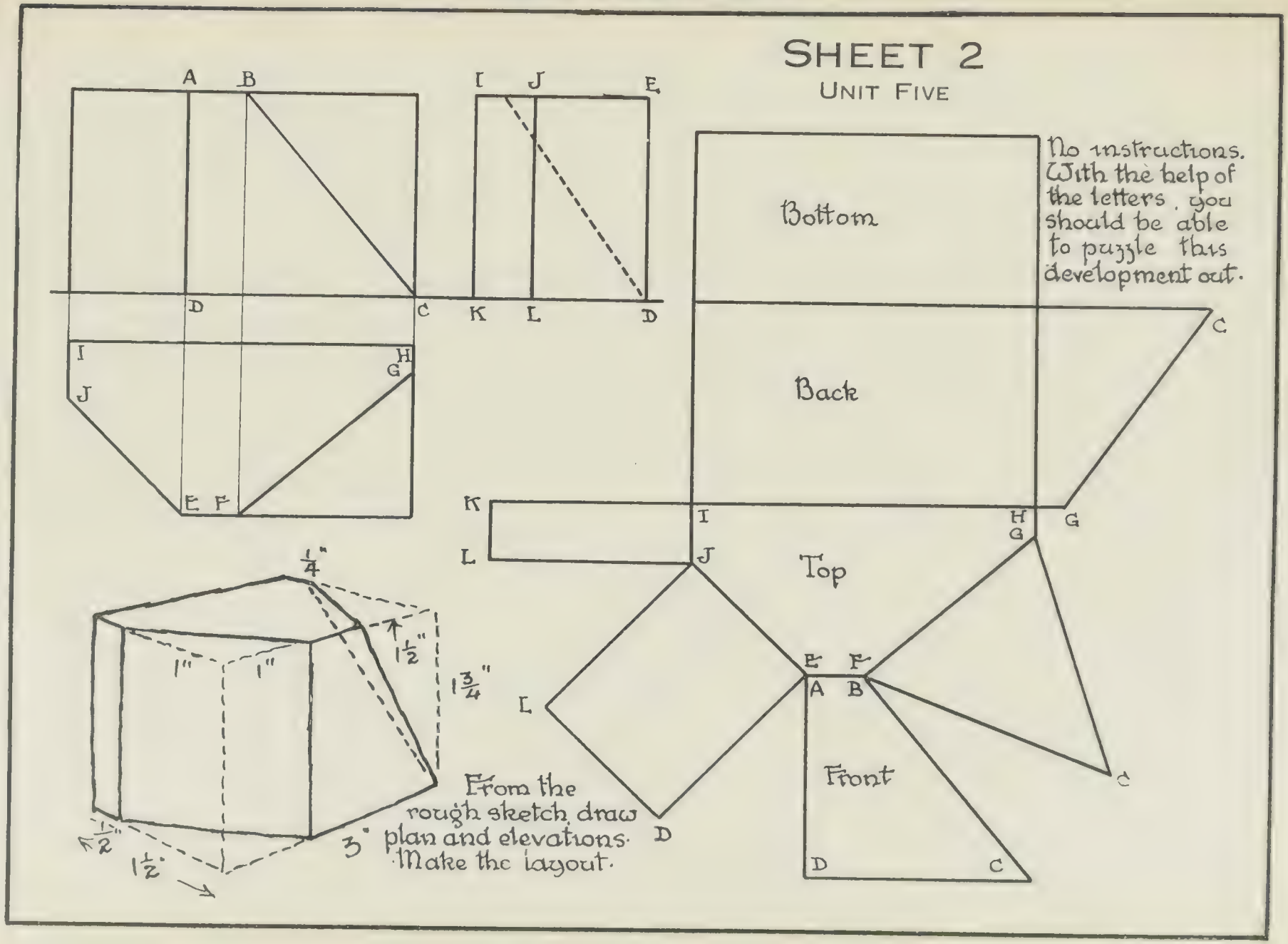
PROJECTION OF CIRCLE.

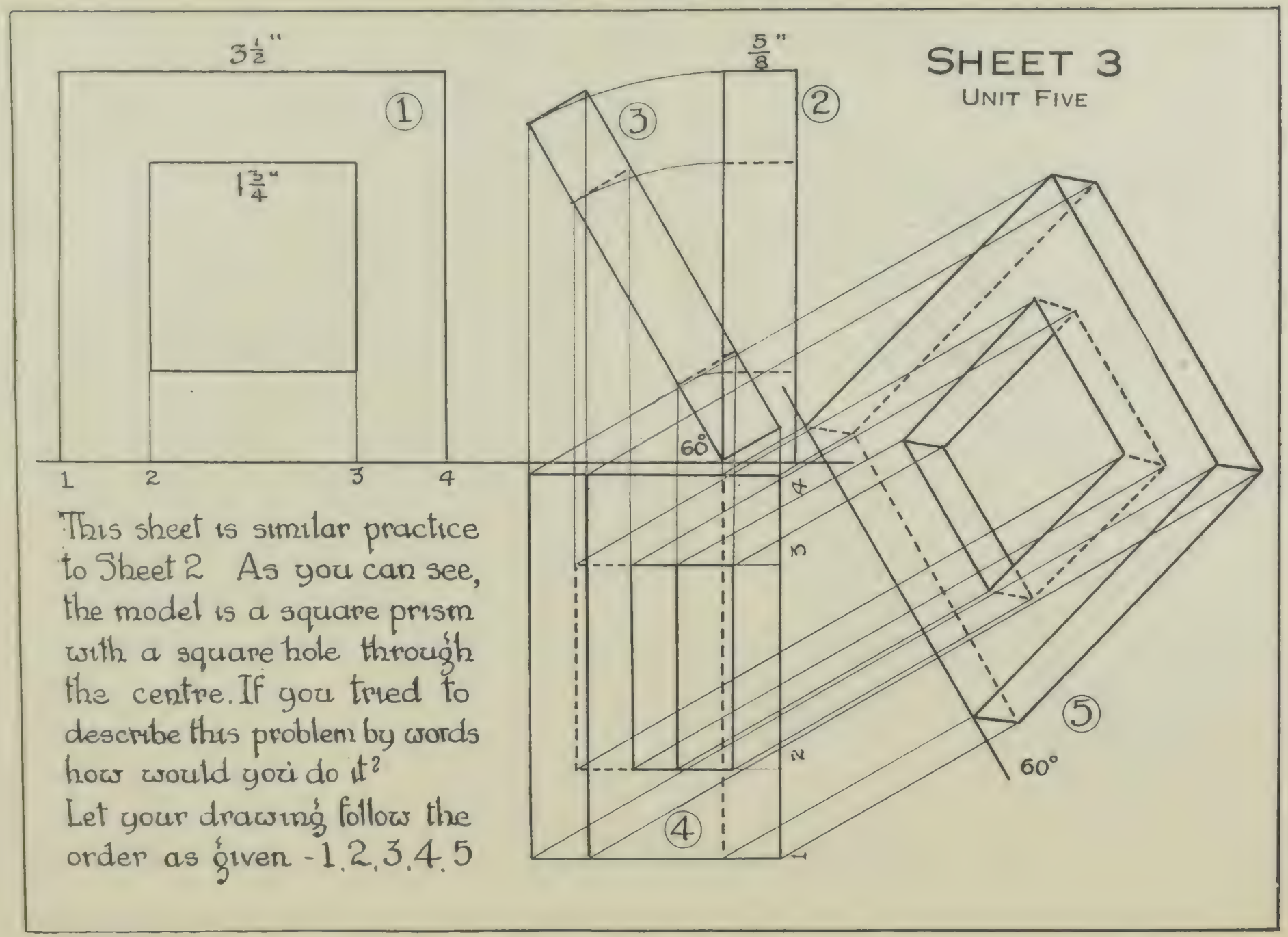
SHEET 1

UNIT FIVE

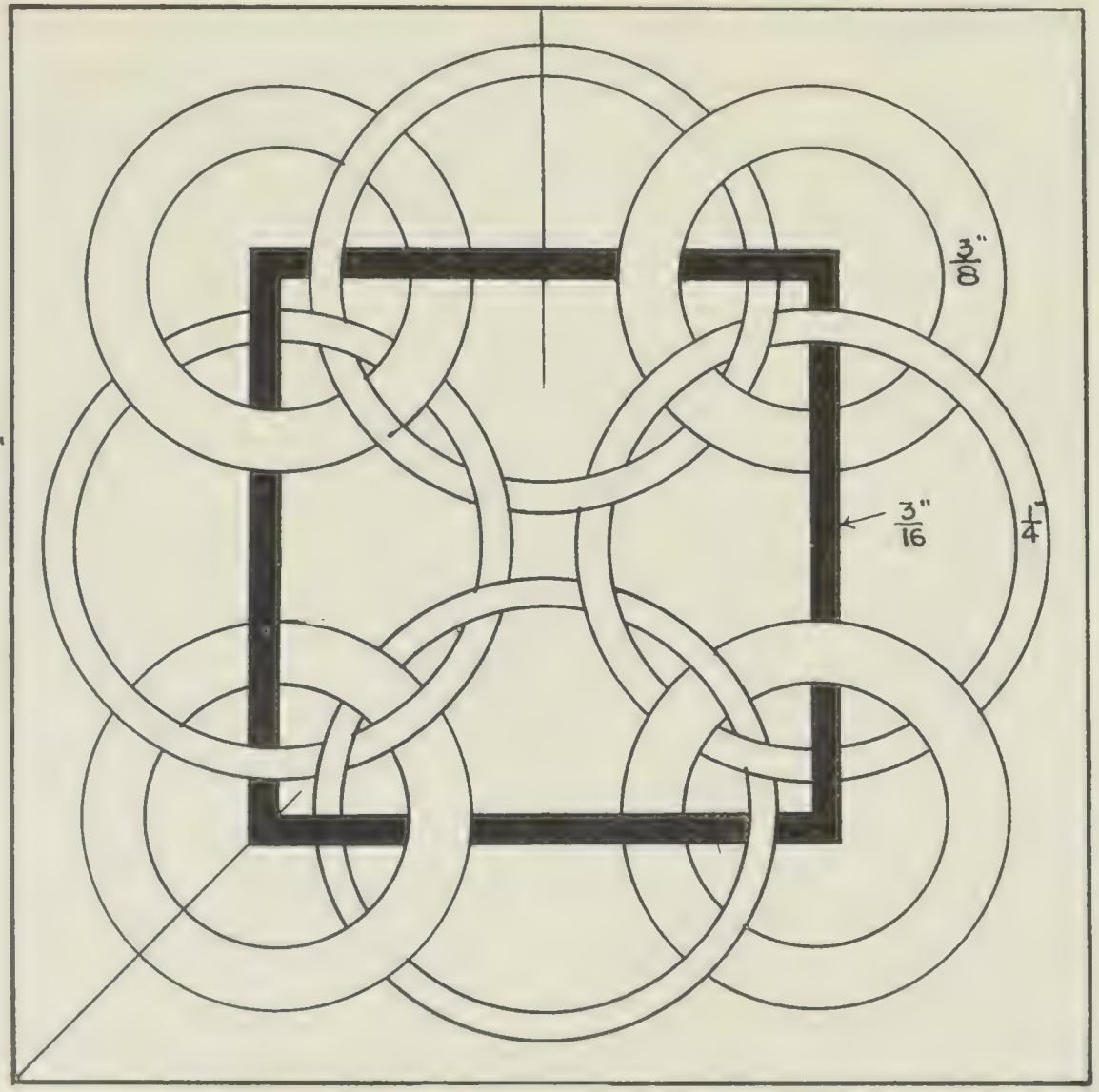
You are given two lines as the plan and elevation of a circle. In the elevation, tip over the circle till it makes 60° with the H.P. Show new plan and new elevations on X'Y' and X^2Y^2. Chase your points along the projectors, and transfer your heights from your elevation.




SHEET 2
UNIT FIVE
A
B
D
C
I
J
E
K
L
D
I
H
G
J
E
F
Bottom
Back
Top
Front
No instructions. With the help of the letters, you should be able to puzzle this development out.
C
K
I
H
G
G
L
J
E
F
A
B
L
C
D
D
C
1/4"
1"
1"
1 1/2"
1 3/4"
1/2"
1 1/2"
3"
From the rough sketch draw plan and elevations. Make the layout.



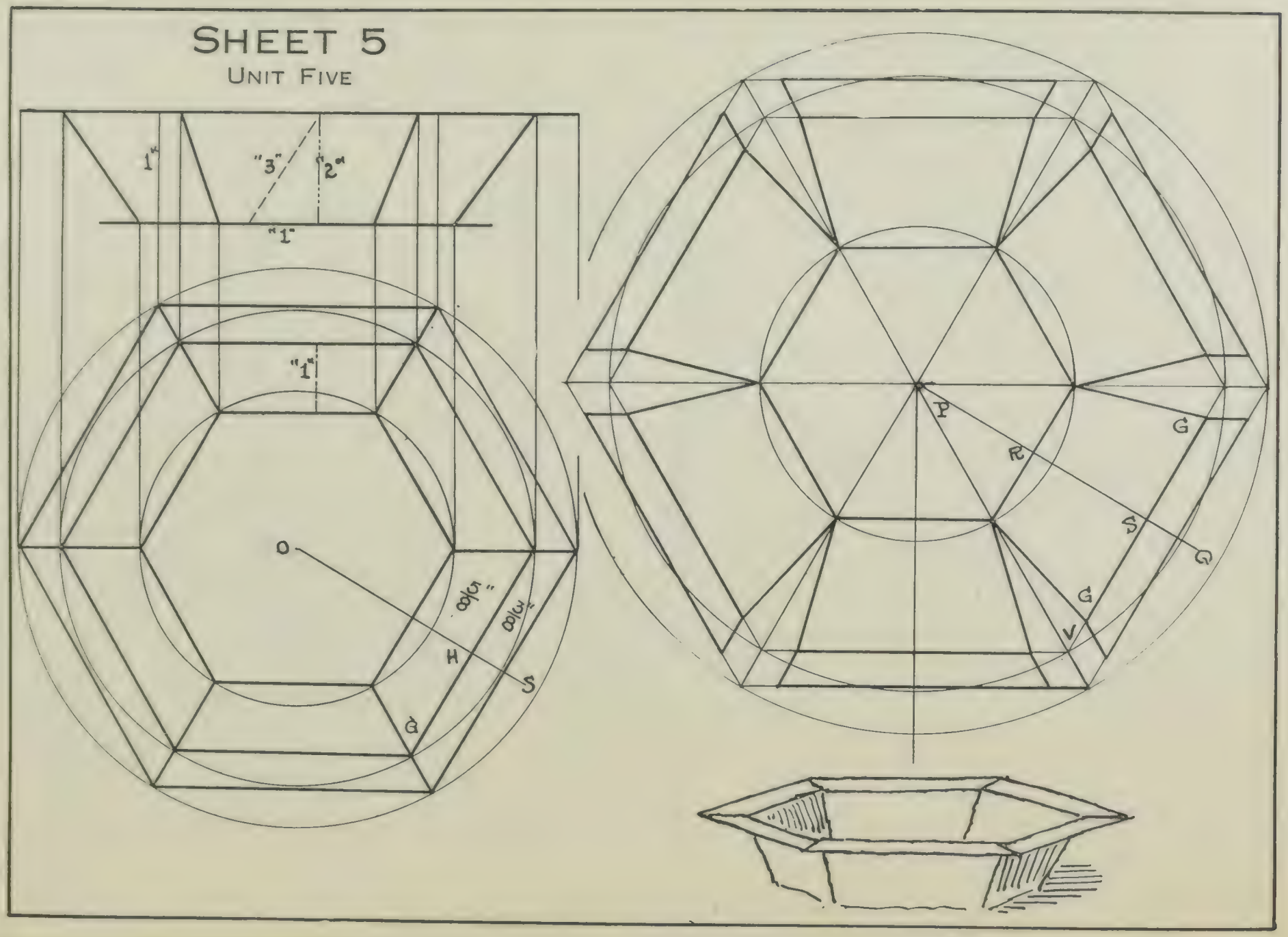
This sheet is similar practice to Sheet 2 As you can see, the model is a square prism with a square hole through the centre. If you tried to describe this problem by words how would you do it?
Let your drawing follow the order as given - 1, 2, 3, 4, 5



TRACERY

SHEET 4
UNIT FIVE

The centre of the large circle is $1\frac{3}{4}$" down middle line The centre of the small circle is $2\frac{1}{2}$" up the diagonal. Work very carefully.


SHEET 5
UNIT FIVE
1"
"3"
"2"
"1"
"1"
O
H
S
G
P
R
S
Q
G
G
V

DEVELOPMENT OF TRAY

This sheet introduces the first of a set of regular solids, all of which are developed on the same lines.

Swing a five-inch circle on your H.P. and place a hexagon in the circle as shown.

Draw the diagonals, and the middle line OS. Place your inner hexagonal ⅜″ away from the first one, and then your inmost hexagon ⅝″ farther in. Harden up your mitre lines, the lines on which the different sides meet. You have now the plan of a hexagonal tray. Why are light circles drawn in the plan?

The height of the tray is 1″. Above your XY draw a line parallel to XY and 1″ above it. Now watch your projection carefully. The six points on the smallest hexagon are on the bottom of the tray, and so must lie on the H.P. Consequently their elevation will be on the XY. Project them so.

The points of the other two hexagons are 1″ above the H.P., and so when projected will hit the 1″ line in the elevation. Project so and you have the complete elevation and a complete readable drawing.

How many true lines do you see in the elevation?

To develop: Swing the circle of your bottom and extend all the diameters. Draw a middle line PQ.

Now imagine the tray to have been under a steam roller. It will all be flattened out and all burst at the corners. It was flattened out like this at first, before it was set up as a tray.

The side RS appears in its true width. It does not do so, either in the plan or elevation. You have to find this true width.

Draw the plan of the width as at "1". Your height is 1″. Place your plan against your height "2" as in the dotted diagram in the elevation, and you get your true width "3".

In your development make RS equal to "3", and draw the inside hexagon in light lines.

To get the gap at the corners: When you look down on your plan, all the sides of the hexagons are true. Lift HG, half the true side, and place it on each side of S in your development, getting the points G, G. Measure GV, and mark it off at all your corners in this hexagon.

To get your rim you could proceed in the same fashion, getting the half of your outside edge from the plan, and transferring.

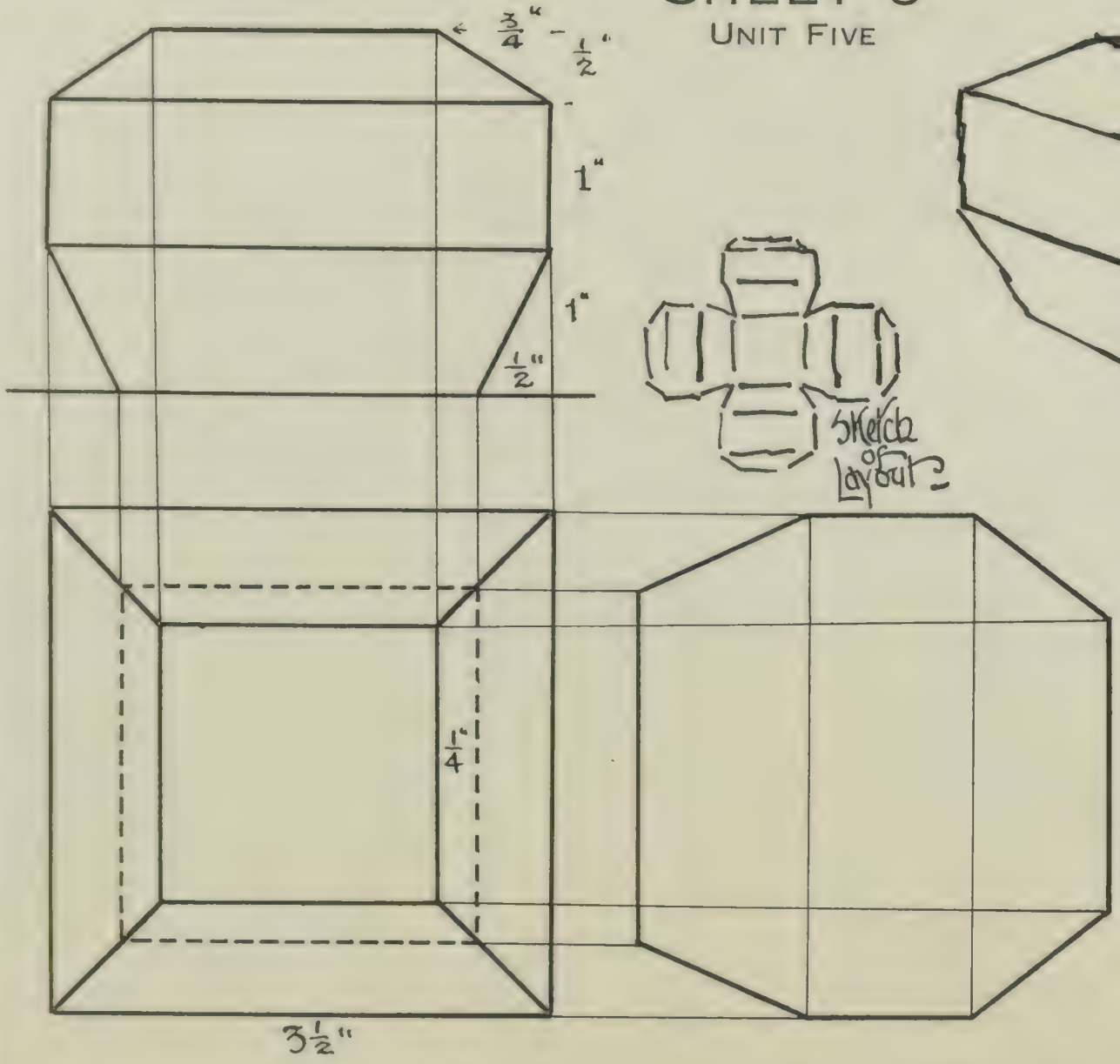
But you will notice that the mitre edges of the rim are all parallel to your diagonals or mitre lines. They must be. As you raise the sides to their permanent positions the mitre edge must keep parallel to your mitre line, and then finally they all meet to make your corner. Thus it is easier and surer to draw parallels than to rely on transferring lengths.

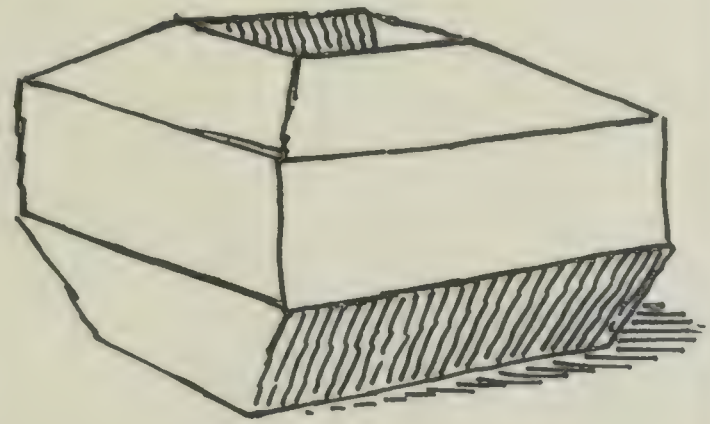
Of course, it is assumed that your side pieces have been laid down correctly.

Prick through a piece of cardboard, cut out and raise.

SHEET 6

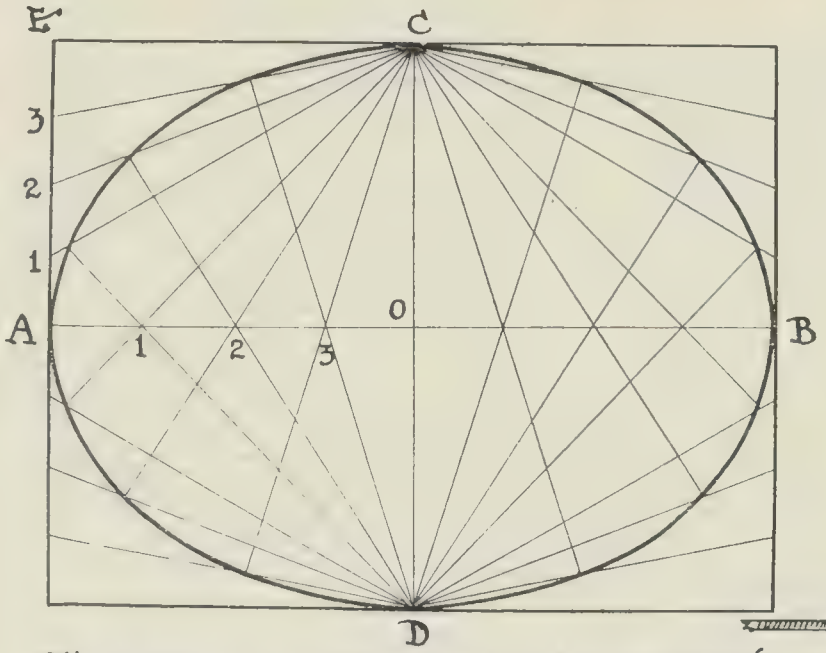
UNIT FIVE

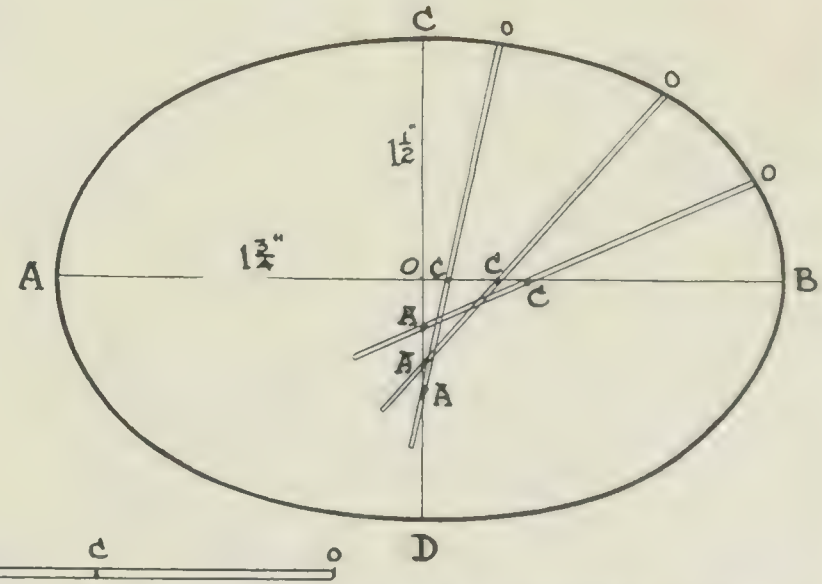




The sketch above is that of a square vase. Show plan, elevation and stretch-out of one of the sides... Transfer the lay-out and the bottom to a piece of cardboard to make a set-up....

ELLIPSES





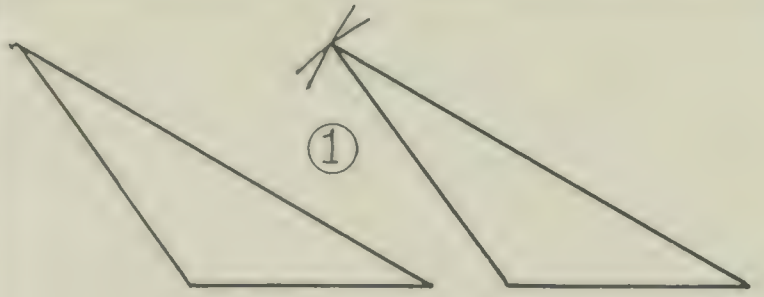
This shows another method of drawing an ellipse.
Divide EA and AO into 4 equal parts.
Connect location lines as indicated

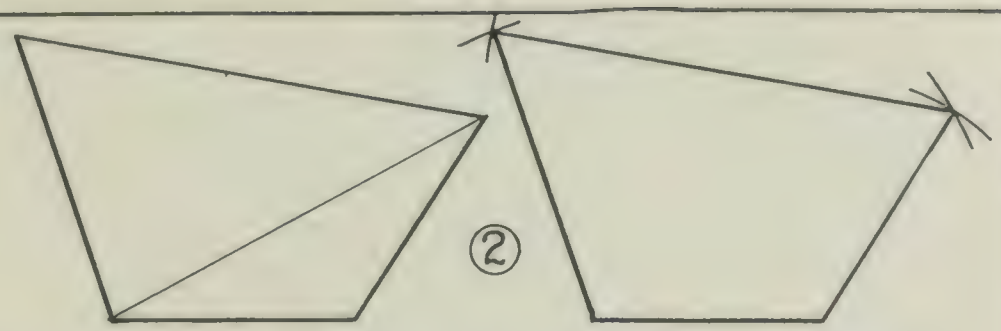
AB is 4½"; CD is 3½".

SHEET 7
UNIT FIVE

Suppose a man had to make an elliptical table 4'6" by 3'. He could not very well use any of the methods already shown. He would draw his major and minor axes as shown. He would then take a trammel or rod, and measure off on it half the major and half the minor axis, as shown. He would place these points always on the two axes as shown, and so would get the curve points.

PROVINCIAL LIBRARY, VICTORIA, B.C.



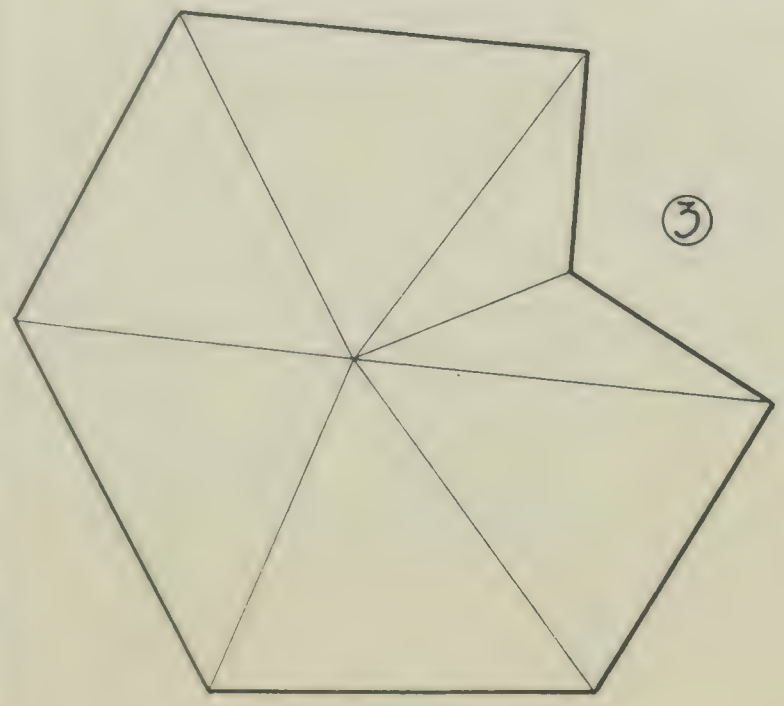


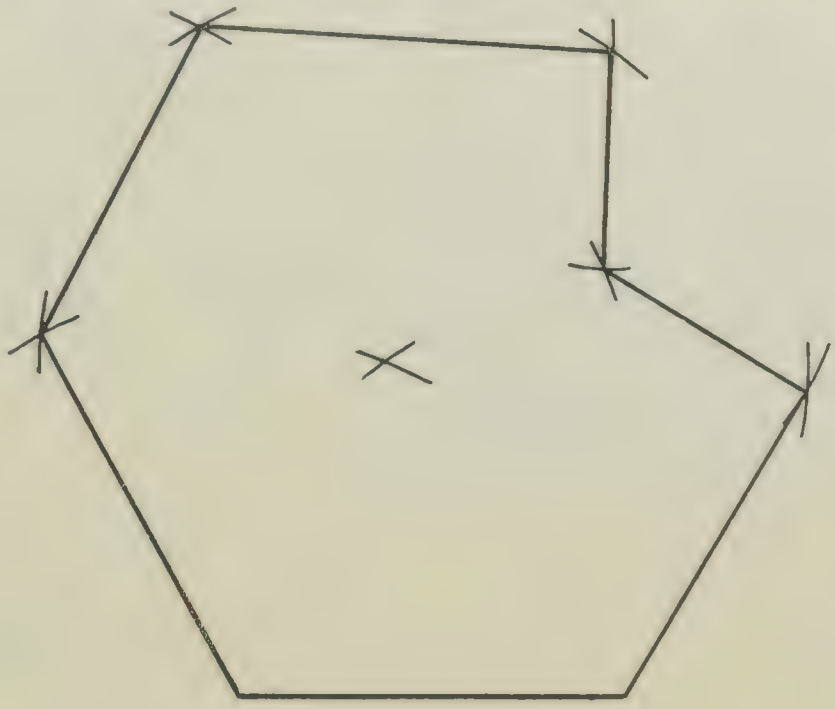
COPYING FIGURES

SHEET 8

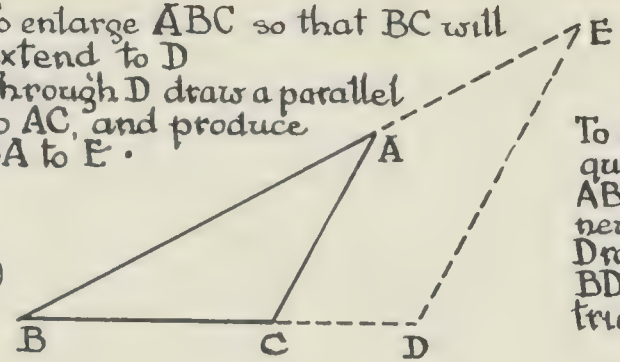
UNIT FIVE

In copying any rectilineal figure you simply divide the figure into triangles, which you copy. In this sheet, make your own figures 1, 2, 3, and copy



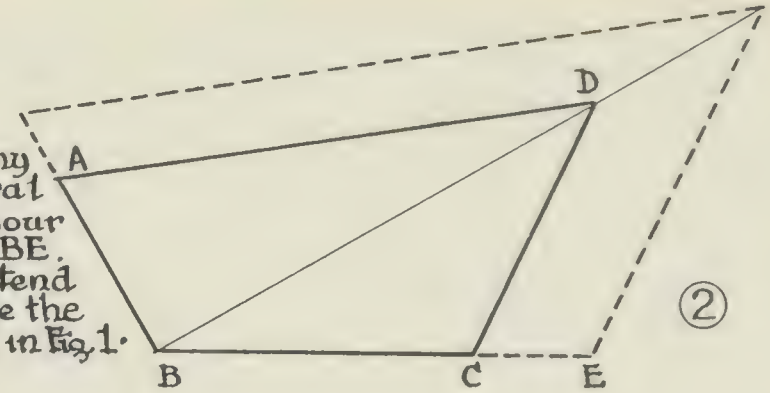


To enlarge ABC so that BC will extend to D
Through D draw a parallel to AC, and produce BA to E.



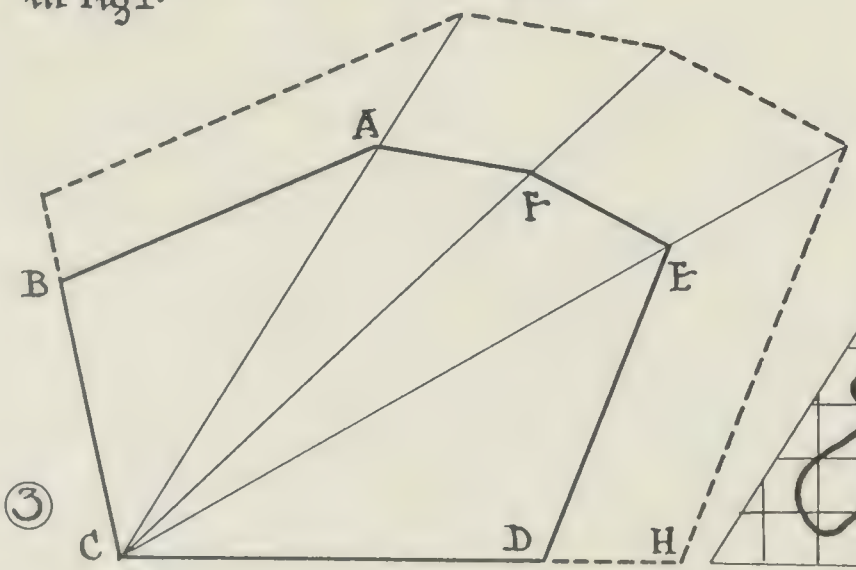
①

To enlarge any quadrilateral ABCD. Fix your new length BE. Draw and extend BD. Enlarge the triangles as in Fig. 1.



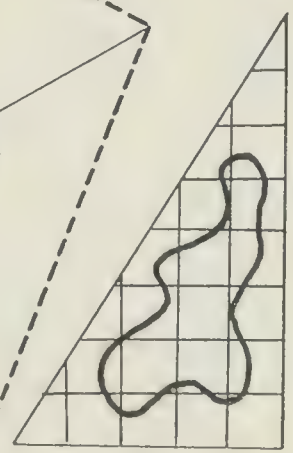
②

To enlarge any polygon as ABCDEF Fix your new length CH. Triangulate from any corner, and enlarge as in Fig 1.



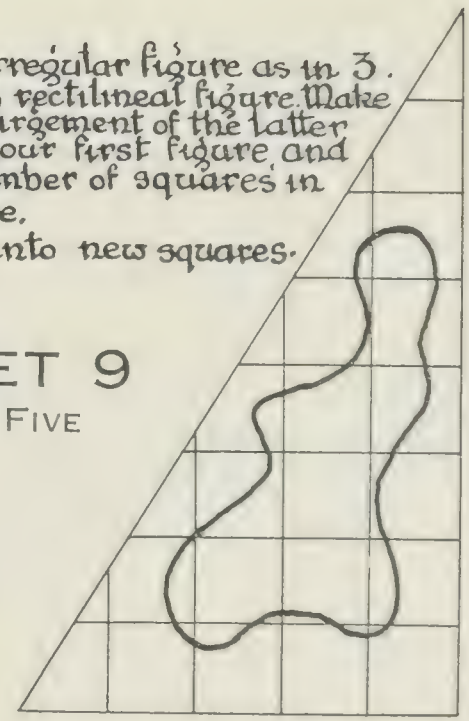
③

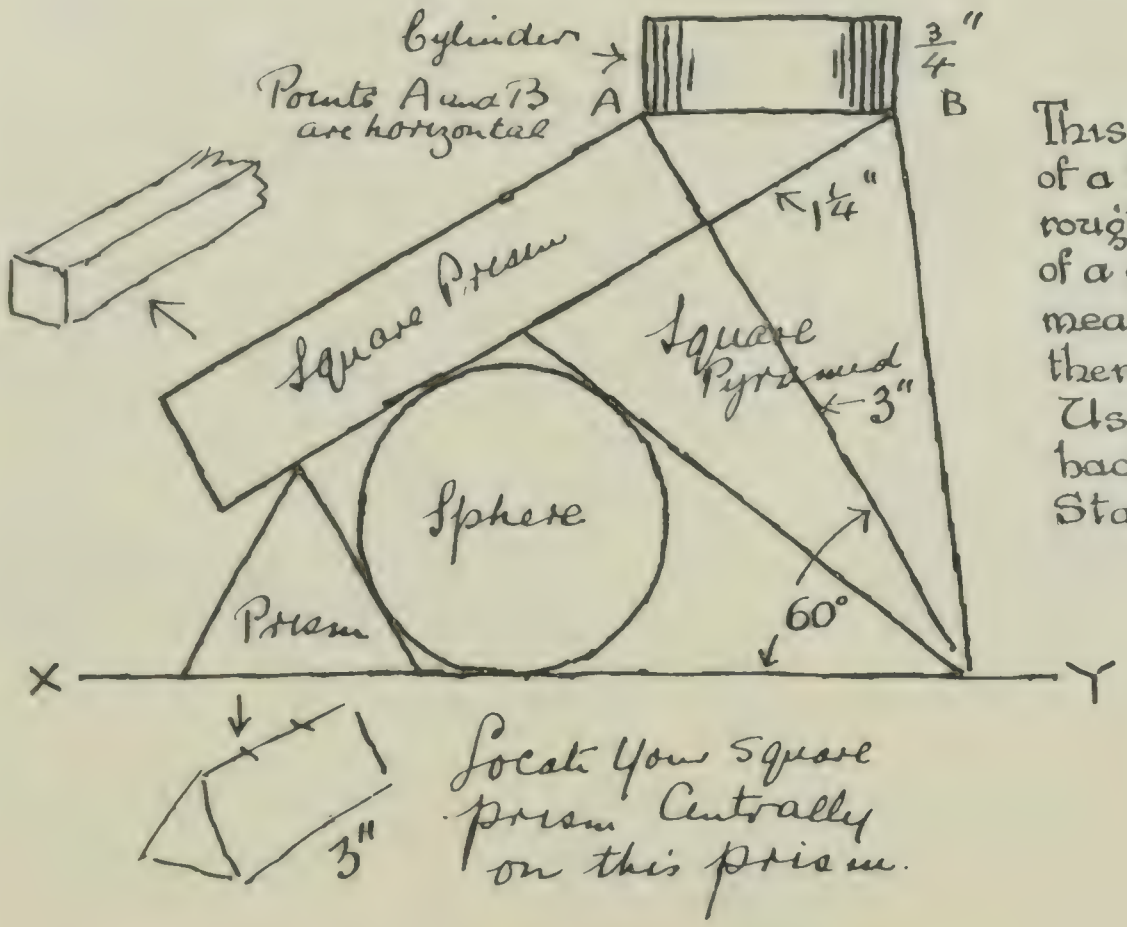
To enlarge any irregular figure as in 3. Enclose with any rectilineal figure. Make the required enlargement of the latter figure. Square your first figure and put the same number of squares in the second figure.
Copy into new squares.



SHEET 9
UNIT FIVE

④





This sheet is in the nature of a test. You are given the rough sketch of the elevation of a group, with all the needed measurements. Some are not there.

Use your head, and turn back for reference.

Start with the pyramid.

SHEET 10

UNIT FIVE

HI